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Software Development for Education Infrastructure Management: Extreme Programming-Based Approach

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Abstract

Education infrastructure in Indonesia faces significant challenges and inequity between urban and rural areas. Differences in education facilities, teacher qualifications, and access to technology are key issues in improving the quality of education across the country. In this context, an efficient education infrastructure system and the software applications that support it are crucial to achieving educational equity. This study adopted the Extreme Programming (XP) software development method to develop an education infrastructure application focusing on school data management. The results of this study show that the education infrastructure application based on the XP method successfully identified the initial requirements strongly and focused on the most essential features. User Acceptance Testing (UAT) provided valuable feedback, highlighting the strengths and weaknesses of the application; the user satisfaction rate was 82%. It was found that the app has the potential to fulfil user needs, although some improvements are needed, especially in certain features such as the Inventory module. Future research could focus on the continued development of the education infrastructure app, taking into account user suggestions and feedback. Further research involves more stakeholders, including parents and students, in testing and improving the app. This research highlights the importance of developing software applications that support equitable and efficient education infrastructure in Indonesia.

Keywords: *Education Infrastructure, Infrastructure Prioritisation Application, Prototype*

1. Introduction

The equitable distribution of education infrastructure in Indonesia is a major challenge that has been the focus of attention for many years. Significant regional disparities are evident, with urban areas often enjoying better education facilities than rural areas. The quality of facilities, distribution of qualified teachers, and access to technology are often better in big cities. In contrast, in remote areas, the quality of education is hampered by inadequate facilities, teachers who need adequate training, and limited internet access. Limited budgets and a lack of efficient planning and management make equalizing education infrastructure difficult. Therefore, equalizing education infrastructure requires a shared commitment and sustained efforts to create equal educational opportunities and better quality education across Indonesia[1], [2].

Educational infrastructure has a very close relationship with the quality of education. The quality of education is influenced by several factors, and education infrastructure is one of the critical factors that play an essential role in determining the quality of education. Educational infrastructure includes classrooms, libraries, laboratories, and other educational facilities. The presence of adequate facilities is essential for creating an effective learning environment. Comfortable and standardized classrooms, well-equipped laboratory facilities, and a sound library can improve the quality of learning. Safe and well-maintained education infrastructure is an essential prerequisite for the safety of

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students and school staff. Poor or unsafe physical conditions can jeopardize student safety and disrupt learning[3], [4].

Access to technology and digital resources is essential in education in the digital age. Infrastructure that supports internet connectivity and modern technological devices enables the use of digital resources in learning, which can improve the quality of education. Education infrastructure also includes labor aspects, such as the qualifications of teachers and school staff. Highly qualified and well-trained teachers play a crucial role in improving education quality[5], [6]. Good education facilities also include libraries with relevant and diverse collections of books. Access to quality learning materials can improve students' understanding and their ability to learn. Education infrastructure includes efficient school administrative and management systems. Good management can improve educational programs' supervision, planning, and implementation. Thus, good education infrastructure provides a solid foundation for better education quality. With adequate facilities, appropriate technology, abundant learning resources, and qualified staff, schools can provide quality education to students. Investing in education infrastructure is an essential step toward improving the quality of education in a country or region[7]–[9].

The education infrastructure system in the education office is essential because it serves as the foundation and framework for managing and improving the quality of the education system. Here are some reasons why education infrastructure systems are needed in education offices: Planning and Management The education infrastructure system helps in planning, managing, and monitoring all aspects of education in the region. This includes budget allocation, resource management, and long-term planning for the development of the education system. The system enables the education office to monitor and evaluate the performance of schools, teachers, and students. It helps identify areas that need improvement and make decisions based on accurate data. With the education infrastructure system, decision-making becomes more informed[10], [11].

The data managed by this system can be used to determine education policies, resource allocation, and development priorities. The system facilitates accurate and timely reporting on school and student performance. This supports accountability at both local and national levels. The system can be used to develop a curriculum plan that suits the region's educational needs. This includes the selection of appropriate textbooks, teaching materials, and learning methods. Education infrastructure helps in the management of teachers and school staff. This includes managing personal data, training data, and teacher qualifications. The system helps maintain and manage educational facilities, including necessary repairs, maintenance, and expansion. Education infrastructure enables the use of technology and digital resources in education. This includes internet access, hardware, software, and applications that support digital learning[12]–[15].

The system assists the education office in managing the available budget, including allocating funds for education infrastructure development, financing education programs, and allocating resources efficiently. With a sound education infrastructure system, the education office can provide better services to the community, including students, parents, and teachers. This includes student registration, grade reporting, and access to education information. With an effective education infrastructure system, the education office can work more efficiently, improve education quality, and ensure equal access to education for all citizens. The system also supports transparency, accountability, and data-driven decision-making[16]–[18].

Application development involves steps and methods to plan, design, develop, and test software applications. The Waterfall method is a linear software development method that consists of a series of sequential phases, such as analysis, design, implementation, testing, and maintenance. Each phase must be completed before starting the next phase. The Agile method is a more flexible and iteration-based approach. The development team works in

short cycles (sprints) to design, develop, and test small features of the application. This method allows for easier changes during development[19]–[23].

Scrum is a project management framework commonly used in Agile-based application development. Teams use daily "stand-up meetings", sprint planning, and retrospectives to organize and oversee project progress. Kanban is a method that focuses on visualizing work as a Kanban board. Teams slide task cards through columns representing the work status, making it easy to see and manage the workflow. The prototyping method involves creating an initial application prototype before developing the final version. This helps in identifying user needs and necessary improvements before further development. The Spiral method is a combination of the Waterfall method and the prototype method. Development is done in iterative cycles focusing on risk control and testing[24]–[26].

DevOps is an approach that combines development and operations to improve collaboration and automation throughout the application lifecycle, including testing and implementation. RAD is a method that focuses on developing applications quickly using existing tools and components. It seeks to reduce development time[27]–[30]. XP is an approach that promotes rigorous development practices and intensive collaboration between the development team and users. It includes iterative testing, continuous integration, and iterative delivery (release). MVC is an architectural approach that separates application components into three main parts: Model (data), View (appearance), and Controller (business logic). This helps in organizing the application code. Each method has its characteristics and uses, and selecting a method depends on the project's needs, resources, and application goals. Some projects may use a mix of these methods to achieve the best results.

2. Reseach Methodology

The development of this application adopts the Extreme Programming approach; the stages in this research consist of 5 main stages: Initial Exploration of Requirements, Iteration Planning, Coding and Testing, Continuous Assessment, and User Acceptance Testing. The research flow is shown in Figure 1.

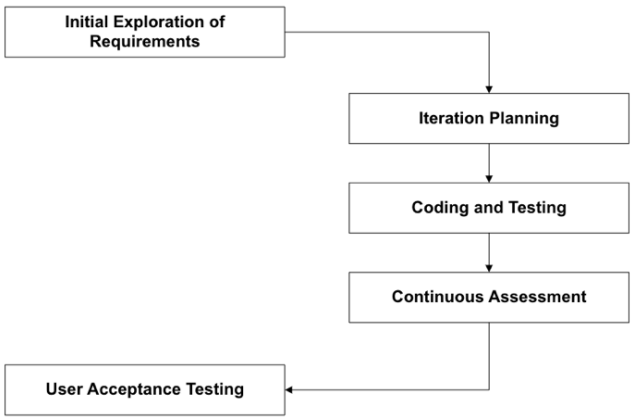

Figure 1. Research Stage

Initial Exploration of Requirements

Identify initial requirements from the education office, schools, and end users (teachers, students, parents). Prioritize the most essential features and functions for initial development.

Iteration Planning

At this stage, determine the features and functions that will be developed during the first iteration. Detail the tasks that need to be completed and estimate the time for each task.

Coding and Testing

We start implementing the features according to the planned tasks at this stage. The coding and testing processes run concurrently. Programmers do unit testing, while testers perform functional and integration testing.

Continuous Assessment

During iterations, the team continuously evaluates the code quality and development progress. This involves code revisions and quick fixes if problems are found. User

Acceptance Testing

Once the iteration is complete, end users, such as teachers or education office staff, test the application and provide feedback. Revisions and improvements are made according to their feedback.

3. Results and Discussion

3.1. Initial Exploration of Requirements

The results of the Initial Exploration of the Requirements stage form a solid basis for continuing the development of the education infrastructure application as show in Figure 2. The established priorities and requirements guide the development process and allow developers to focus on the features and functions that significantly impact users and education.

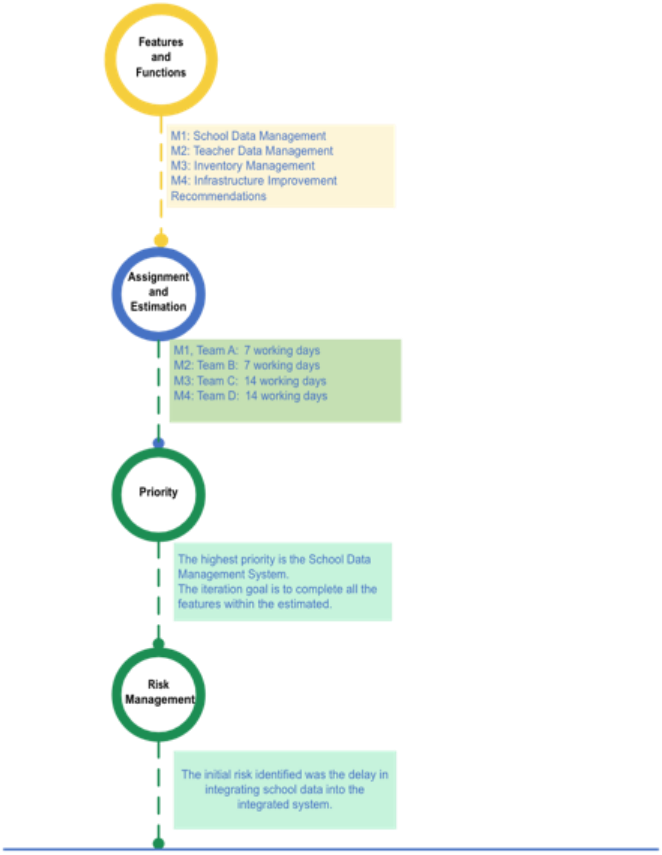

Figure 2. Iteration Planning

3.2. Coding and Testing

The "Coding and Testing" stage in developing educational infrastructure applications is one of the essential steps in the software development cycle. In this study, the development data includes the features developed, the tasks to be completed, the estimated time, and the programmers responsible. Next, a description of the coding and testing process highlights the Programmer's role in implementing the features.

Table 1. Featured Developed

Features developed	Lesson Scheduling Module
Task	Lesson scheduling algorithm coding
Estimated Time	10 working days
Responsible programmer	4 programmer

During coding, the Programmer performs unit testing to ensure that each user interface component functions correctly. Unit testing is a common practice in software development, where each component or function is checked separately to ensure that they operate as expected. This is important to minimize the possibility of bugs or more significant problems at a later stage.

Upon completion of coding, the resulting module is given to the Tester for functional and integration testing. The Tester is responsible for verifying that the user interface works as expected. Functional testing checks whether the module fulfils the pre-defined functional requirements. In addition, integration testing ensures that the module interacts with other components in the application harmoniously.

Table 2. Coding and Testing Process

Stage	Programmer
Tasks	Coding the lesson scheduling algorithm
Unit Testing	Ensuring modules function correctly
Functional Testing	Verifying inventory meets requirements
Integration Testing	Ensuring integration with other modules
Testing Results	Minor bugs related to infrastructure sharing
Action	Programmer X fixes the bugs
Final Result	The lesson scheduling module is ready to use

During the testing phase, the Tester found some minor bugs, which the Programmer fixed. This process reflects the importance of early collaboration between programmers and testers in finding and fixing problems. Most notably, the bugs found were identified and fixed quickly, minimizing their impact on the overall development.

3.3. Continuous Assessment

The results of Continuous Assessment ensure that code quality and development progress are maintained and improved throughout the development process. This process involves continuous evaluation, issue identification, and prompt corrective action.

a) Code Quality Evaluation Methods:
   Use of code static analysis tools to identify potential problems in the code.
b) Frequency of Evaluation:
   Code evaluation is performed weekly, especially after adding features or significant changes in the code.
c) Recent Evaluation Results:
   In the most recent evaluation, the code static analysis tool identified several potential issues in the lesson scheduling module.
d) Types of Issues Found:
   Some issues found included ill-defined variables, high code complexity, and lack of documentation comments.
e) Corrective Action:
   Programmers perform code revisions to fix ill-defined variables, reduce code complexity, and add necessary documentation comments.

f) Quality Testing:
After the code fix, the Tester performs functional testing again, verifying that the identified issues have been fixed successfully.

Continuous Assessment results show that the application code is always in a better condition, with potential issues identified and fixed quickly. This helps ensure that education infrastructure applications remain high quality throughout development and that minor issues do not develop into significant, intractable problems later on.

3.4. User Acceptance Testing

User Acceptance Testing (UAT) as shown in Figure 3 is an essential stage in the software development process, and the data provided highlights the importance of this stage in developing education infrastructure applications. In the first development iteration, 20 testers, including 10 teachers and 10 education office staff, were involved to evaluate how the application met their needs and functioned as expected. UAT was conducted for 5 days after the completion of the first iteration.

User Feedback and Satisfaction:
Feedback received from UAT participants provided valuable insights into their experiences with the application. Key points noted included the ease of use and usefulness of the School Data Management System features in tracking student progress. This is a positive indicator that the app fits the needs of users. The Inventory module, while helpful in optimizing the use of classrooms, was recognized as needing improvement, particularly regarding QR code printing. This feedback emphasizes the importance of fine-tuning certain features to improve user experience.

In addition, the teacher profile feature received positive feedback, although there was a minor issue with the profile picture. This shows that the app has promising features but needs to be refined to reach its full potential. The user satisfaction rate of 82% indicates that the app is generally well-received, but there is still room for improvement. User feedback is essential in guiding future development.

Post-UAT Actions:
Post-UAT actions demonstrated the development team's responsiveness to user feedback. They immediately addressed the profile photo display issue, demonstrating a commitment to quickly resolving it. In addition, improvements were made to QR code printing in the Inventory module on user suggestions. This proactive approach towards addressing user feedback ensures that the app will be more controllable and better suited to user needs in subsequent iterations.

User Acceptance Testing is essential in software development, including education infrastructure applications. Feedback from teachers and education office staff provided valuable insights that guided the refinement of the app to meet users' needs better. Post-UAT actions demonstrate the development team's commitment to continuously improving the quality of the app and the user experience. As the app progresses to the next iteration, addressing user feedback will be critical to ensure it becomes an effective tool for educational institutions.

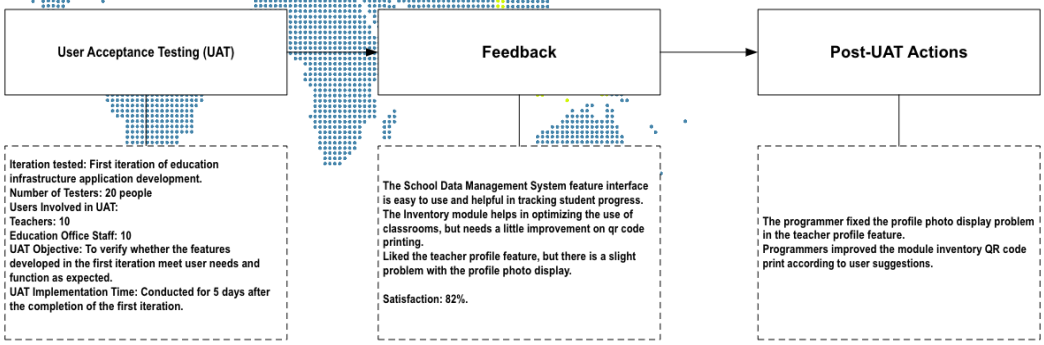

Figure 3. User Acceptance Testing

4. Conclusion

The education infrastructure system plays a crucial role in managing and improving the quality of the education system. It helps in planning, managing, reporting, and supervising all aspects of education. The system also supports the development of a curriculum that suits the region's educational needs. The development of the education infrastructure application used the XP approach and involved five main stages: Initial requirements identification, iteration planning, coding and testing, continuous evaluation, and user acceptance testing. The results of the application development stages show the importance of initial solid requirements identification to guide development. User acceptance testing is essential in evaluating the extent to which the application meets user needs and provides feedback that guides subsequent improvements. Post-UAT actions demonstrate the responsiveness of the development team to user feedback, with a commitment to improving the app's quality.

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