
Development of an AI-Based Digital Report Card Information System for Automated Student Progress Description Generation Using the Waterfall Method

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Keywords

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Abstract

The preparation of early childhood student report cards is still predominantly performed manually, resulting in time-consuming administrative processes, inconsistent narrative assessments, and increased teacher workload. Despite the growing adoption of educational information systems, limited studies have integrated Generative Artificial Intelligence (AI) to automate developmental narrative generation in early childhood education. This study aims to develop a web-based Digital Report Card Information System that integrates the Gemini API to automatically generate individualized developmental narratives based on teachers' assessment data. The system was developed using the Waterfall software development methodology, encompassing requirements analysis, system design, implementation, and testing. PHP and MySQL were used to develop the application, while the Gemini API generated narrative evaluations according to predefined developmental assessment indicators. The resulting system provides comprehensive functionalities, including student, teacher, and class management, developmental assessment, anecdotal records, principal approval, parent access, and automated digital report card generation. System implementation demonstrates that the proposed solution streamlines report preparation, facilitates assessment data management, and produces more consistent developmental narratives, thereby supporting academic administrative services at PAUD Terpadu Restu 2. These findings demonstrate the potential of integrating Generative AI into educational information systems to support digital transformation and improve assessment practices in early childhood education.

1. Introduction

The advancement of information technology has brought significant changes to many sectors, including education, where its use now extends beyond the teaching and learning process into the management of academic administration. One important aspect of educational administration is the assessment and preparation of student report cards, which directly affects the quality of communication between schools and parents regarding a child's development [1].

KB – BA – TPA Restu 2 Malang, as an early childhood education (ECE) institution, plays an important role in monitoring and assessing children's development across cognitive, behavioral, and physical aspects. However, the assessment and report card preparation process is still carried out manually, using notebooks and simple documents. This practice leads to several problems, including difficulty in data management, a high risk of recording errors, and an inefficient report card preparation process [2].

In addition, assessment in early childhood education does not rely solely on numerical scores; it also covers developmental indicators, anecdotal notes, activity records, and narrative descriptions of each child's progress. This complexity makes manual data management increasingly difficult and poorly structured, particularly as the number of students grows [3]. A computerized, integrated solution is therefore needed to support the entire child-development assessment process, including the time-consuming task of writing narrative descriptions for every student each semester [4], [5].

Previous studies have examined digital report card and academic information systems, generally focusing on the storage and presentation of numerical assessment data [6]. However, limited attention has been given to early childhood education, where assessment is narrative in nature and where teachers must compose individualized developmental descriptions for every child, creating a substantial workload that is prone to inconsistency in quality and language across students [7], [8].

This research addresses that gap by developing a web-based Digital Report Card Information System that integrates Generative Artificial Intelligence through the Gemini API to automatically generate narrative descriptions of children's development based on assessment indicators entered by teachers, in line with the growing body of research exploring the integration of generative AI technologies into educational systems and processes [9] , [10] . The novelty of this research lies in combining structured, multi-role child-development assessment management (covering assessment scores, anecdotal records, activities, and physical growth data) with AI-assisted narrative generation specifically tailored to the early childhood education context, an integration that has not been widely explored in prior digital report card systems[11].

The urgency of this research stems from the increasing administrative burden faced by teachers, the risk of inconsistent and inaccurate manual records, and the lack of timely access for parents to their child's developmental information. The system was developed using the Waterfall methodology, consisting of requirements analysis, system design, implementation, and testing, and is intended to contribute a practical, technology-based solution that improves the efficiency, accuracy, and transparency of child-development reporting at KB – BA – TPA Restu 2 Malang, while serving as a reference for similar digital transformation efforts in other early childhood education institutions.

2. Research Methods

This research adopts the Waterfall model, a linear and sequential software development approach in which each stage must be completed before proceeding to the next [12] . This method was selected because its structured and sequential nature suits the development of the Digital Report Card Information System (SIRADA) for KB – BA – TPA Restu 2 Malang, a system whose requirements, design, and features could be defined clearly from the outset. The development process consisted of four stages: requirements analysis, system design, coding, and testing.

The first stage, requirements analysis, was carried out through direct observation at KB – BA – TPA Restu 2 Malang and interviews with relevant stakeholders, including the school principal, teachers, and administrative staff. This stage focused on the existing manual process of child-development assessment and

report card preparation. From this analysis, the system requirements were identified, covering student and teacher data management, development-indicator management, child assessment, and the digital report card generation feature.

The second stage, system design, was conducted based on the results of the requirements analysis. The design process included the system workflow, use case diagrams, activity diagrams, and database design. In addition, the system module structure was designed, comprising data management, child-development assessment, anecdotal records, and automatic report card generation modules. This stage aimed to provide a comprehensive overview of the system prior to implementation.

The third stage, coding, involved building the system based on the design that had been produced. The system was developed as a web-based application using the PHP programming language and a MySQL database. Implementation covered the login feature, management of student, teacher, and parent data, input of child-development assessments, and digital report card generation. At this stage, the Generative Artificial Intelligence feature was also implemented through the Gemini API to automatically generate narrative descriptions of children's development based on the assessment points entered by teachers.

The fourth stage, testing, was conducted to ensure that all system features functioned according to requirements. Testing was performed using the blackbox testing method, in which each system function was evaluated based on its input and output. Testing covered all modules, from the login process and data management to report card generation, including the automatic narrative-generation feature, to ensure the system operated accurately and with minimal errors before being used by end users.

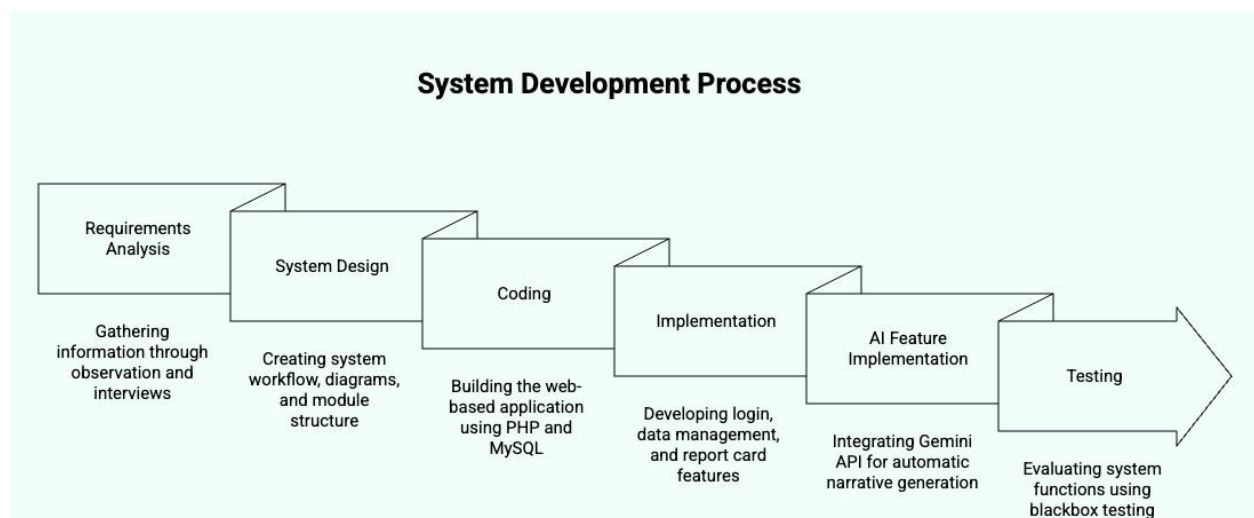


Fig. 1 System Development Process

By applying these four Waterfall stages — analysis, design, coding, and testing — the development of the Digital Report Card Information System was carried out systematically [13], [14], resulting in a system that aligns with the actual needs of KB – BA – TPA Restu 2 Malang.

3. Result and Discussion

The development of the Digital Report Card Information System (SIRADA) resulted in a web-based application that supports six user roles: Superadmin, Administrative Staff (Tata Usaha), Homeroom Teacher (Wali Kelas), Religion Teacher, Principal, and Parent, each with access rights tailored to their responsibilities. The system manages student, teacher, and class data, child-development assessment, anecdotal records, a tiered approval workflow, and an automatic digital report card generation feature.

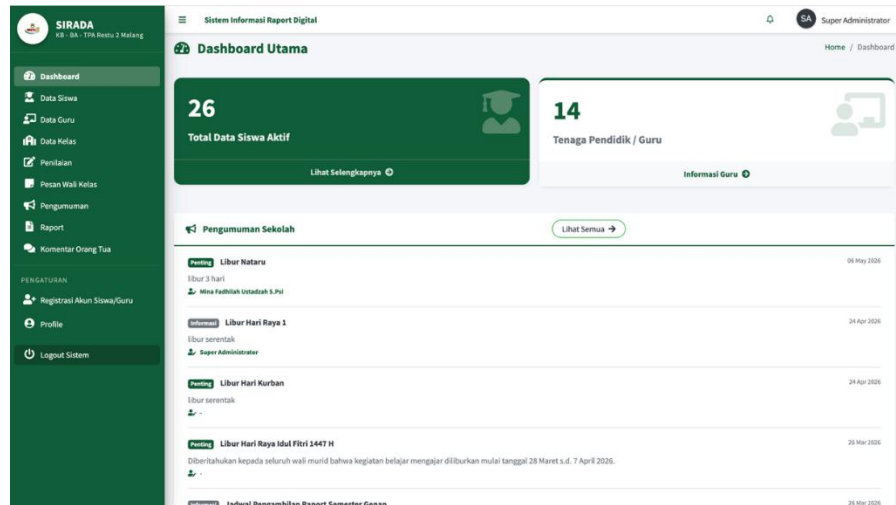


Fig. 2 Dashboard Interface

A key feature of the system is the integration of the Gemini API to automatically generate narrative descriptions of children's development. Teachers input assessment points for each developmental aspect — including religion, identity, literacy, and project-based learning (P5/PjBL) — and the system automatically composes a coherent narrative description based on these points, replacing the manual narrative-writing process that previously had to be done individually for every student[15].

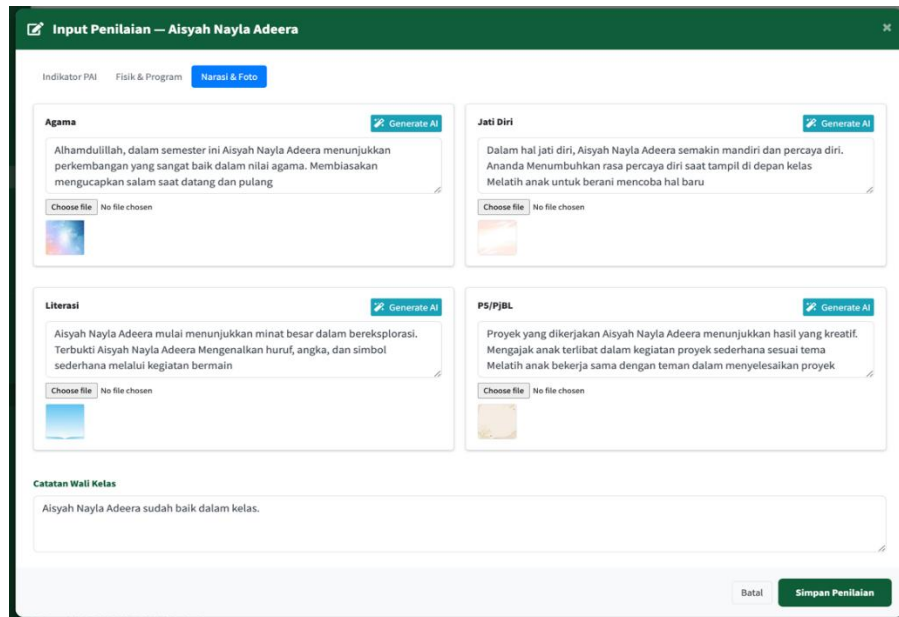


Fig. 3 AI-Based Narrative Generation Interface

This feature directly addresses the workload and inconsistency issues identified in the introduction, as teachers no longer need to compose each child's narrative description from scratch.

The report approval workflow was also implemented as part of the system: after a Homeroom Teacher completes the assessment input and generates the report, the Principal can preview, approve, or return the report with revision notes through the system before it is published to parents.

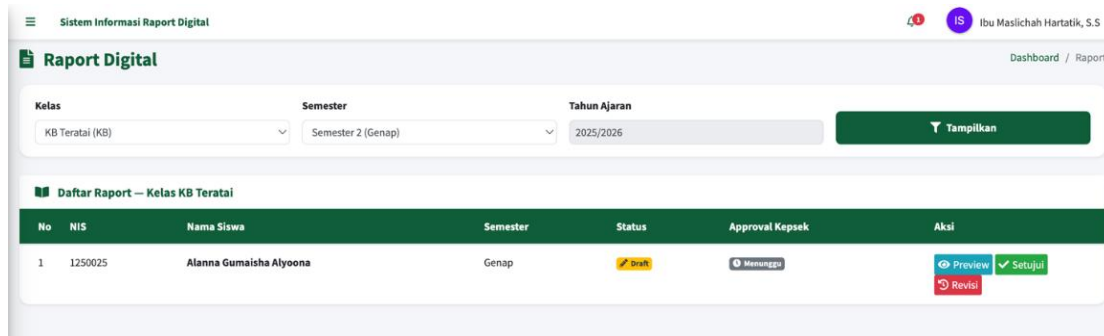


Fig. 4 Principal Approval Preview

This tiered approval mechanism increases the accuracy and accountability of the report content prior to distribution, an aspect not addressed in previous report card system studies that primarily focused on numerical score storage[16].

System testing was carried out using the black-box testing method, covering all modules from login and data management to report generation, including the automatic narrative-generation feature. Functional, security, and interface aspects were verified, including the rejection of login attempts using unregistered credentials, protection against SQL injection on the login form, and confirmation prompts before account deletion. The testing results showed that these functions operated correctly according to the specified requirements.

Table 1. Summary of System Functional Testing Results

Module	Tested Function	Result
Authentication	Login validation and access control	Passed
Master Data	Student, teacher, class, and parent data management	Passed
Assessment	Developmental assessment input	Passed
AI Narrative Generation	Automatic narrative generation using Gemini API	Passed
Approval Workflow	Principal review, approval, and revision notes	Passed
Parent Portal	Parent access to approved report cards	Passed
User Activity	Last-login timestamp recording	Failed

Further evaluation through User Acceptance Testing (UAT) was conducted on 27 April 2026 by a representative of the school partner. The system was tested from the Super Administrator role across 25 test items covering dashboard access, account registration, access-control differentiation, database management, profile management, and core system functionality. Of the 25 items tested, 24 items were declared successful, resulting in a success rate of 96%, while one item, namely the recording of users' last-login timestamp, was found to be non-functional and was identified as an area for future improvement [17].

Tester: Eko Suprianto, S.Psi
 Testing Role: Super Administrator
 UAT Date: 2026-04-27

Browser/Device: Laptop
 Scenario: -

Total: 25 Completed: 25 Passed: 24 Failed: 1 Progress: 100%

CODE	TEST ITEM	STATUS	REMARKS
ADM-01	Can the Super Administrator access the Dashboard page displaying a summary of the total number of students and teachers?	PASSED	-
ADM-02	Does the "User Registration" feature (register.php) function properly for registering new teachers?	PASSED	-
ADM-03	Can the system distinguish access rights between the Super Administrator and Teacher?	PASSED	-
ADM-04	Can the Super Administrator manage the database using the cek_tabel.php script or its equivalent?	PASSED	-
ADM-05	Is the updated profile photo from profile.php successfully stored in the database?	PASSED	-

Fig. 5 User Acceptance Testing Result

These results indicate that the developed system meets the functional requirements identified during the requirements analysis stage, successfully integrating child-development assessment management with AI-based narrative generation [18]. Compared to previous digital report card and school information system studies, which generally focused on data storage and presentation, this research demonstrates that the addition of a Generative AI component for automatic narrative generation provides a practical solution to the specific administrative burden faced by early childhood education teachers, supporting the novelty and contribution claimed in the introduction [19] [20].

4. Conclusions

This research successfully designed and developed SIRADA Restu 2, a web-based Digital Report Card Information System that integrates Generative Artificial Intelligence through the Gemini API to automatically generate child-development narrative descriptions. The system supports student, teacher, class, assessment, anecdotal record, approval, parent access, and digital report card management. By combining structured assessment data with AI-assisted narrative generation, the system helps reduce manual report preparation, improve narrative consistency, and support more efficient academic administration at KB-BA-TPA Restu 2 Malang.

User Acceptance Testing conducted with the school partner showed that 24 out of 25 test items were successfully completed, resulting in a 96% success rate. One remaining limitation was identified in the last login timestamp recording feature, which requires further refinement. Future development may include real-time parent notifications, WhatsApp Gateway integration, graphical development reports, broader multi-role UAT, and stronger security mechanisms, including encrypted password storage and improved activity logging.

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