
Development of an Integrated Web-Based Academic and Administrative Information System with E-Learning and Student Interest Recommendation

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Abstract

The advancement of information technology in the education sector has driven the need for digital transformation in managing academic and administrative processes, including in Early Childhood Education (ECE) institutions. However, many ECE institutions, such as BKB PAUD Bougenville, still rely on manual and fragmented systems for managing student data, attendance, assessments, and learning materials, which often leads to inefficiencies, data inconsistencies, and delays in information processing. This study aims to develop an integrated web-based academic and administrative information system that incorporates e-learning features and student interest recommendations to support more effective and structured educational management. The system is developed using the Agile methodology, which emphasizes iterative development, continuous user involvement, and adaptive improvements based on user feedback to ensure alignment with real operational needs. The proposed system integrates several core modules, including student data management, attendance recording, e-learning through digital materials (e-books), assessment processing, and a data-driven student interest recommendation feature. The implementation results indicate that the system is able to improve data management efficiency, facilitate real-time access to academic and administrative information, and reduce the risk of data inconsistencies. In addition, the interest recommendation feature provides practical benefits by assisting teachers in identifying student potential and supporting more informed decision-making processes. Therefore, this research contributes to the development of an integrated, user-friendly, and adaptive digital platform that enhances the quality of academic and administrative services in the PAUD environment.

1. Introduction

Digital technology has reshaped how educational institutions operate, and Early Childhood Education (ECE) is no exception [1]. Schools at this level face growing pressure to move away from paper-based workflows toward systems that can handle student records, attendance, and reporting in a more reliable way [2]. Yet in practice, many ECE institutions still depend on manual methods, handwritten forms, standalone spreadsheets, and physical filing which regularly cause duplicated entries, slow reporting cycles, and limited oversight of day-to-day operations [3]. BKB PAUD Bougenville is one such institution. At the time of this study, its student records were scattered across paper documents and individual digital files, making it difficult to retrieve or update information quickly. Attendance logs and developmental assessments were recorded by hand, which delayed end-of-period recapitulation and introduced inconsistencies between reports. Learning materials had no centralized repository, and no platform existed to deliver digital learning activities. Taken together, these conditions meant that the institution's existing processes could not keep up with its operational needs.

Research in this area has shown that web-based systems can improve how educational institutions manage data and share information [4]. E-learning platforms, meanwhile, have been found to increase both the flexibility and interactivity of teaching [5]. Still, most published work treats academic management and digital learning as separate concerns rather than parts of a single integrated system [6]. At the ECE level specifically, few studies have explored how children's developmental data can be used to generate interest-based recommendations, even though such information is valuable for guiding early education decisions [7].

Given these gaps, this study set out to build an integrated web-based system for BKB PAUD Bougenville that brings together academic management, administrative processes, e-learning, and a student interest recommendation feature on one platform. The system stores and organizes data centrally, supports digital learning through uploaded materials, and produces recommendations grounded in children's developmental profiles [8]. Development followed the Agile methodology to allow for iterative adjustments based on direct user feedback [9]. Prior studies have largely addressed academic management or e-learning separately, without integrating both alongside a student recommendation feature in an early childhood education context [3][6]. Machine learning approaches for student developmental profiling at the ECE level also remain limited [8]. This study addresses both gaps by building an integrated system that combines academic management, administrative processes, e-learning, and a student interest recommendation feature within a single platform. The recommendation component applies Agglomerative Hierarchical Clustering on six developmental aspects from Permendikbud No. 137/2014 [10], tailored to the needs of Indonesian early childhood education institutions.

2. Research Method

This study adopted the Agile methodology, an approach built around short development cycles where working software is delivered, tested, and revised before moving on [11]. Agile was chosen over a linear development model because the requirements at BKB PAUD Bougenville were not fully fixed at the outset — teachers and staff discovered new needs as they saw early versions of the system, and the methodology needed to accommodate that [12]. Rather than locking down every specification before writing code, the team built the system in stages, gathered feedback after each one, and folded that feedback into the next stage [13].

The system was built across five sprints over roughly 3.5 months, from January to May 2026 [14]. A pre-development phase came first, covering user interviews, field observation, and backlog preparation. Sprint 1 set up the foundation: Laravel setup, database structure, public pages, and user authentication. Sprint 2 handled core data management for teachers, classes, and students. Sprint 3 added scheduling, attendance, and e-learning features. Sprint 4 was the most substantial sprint, covering financial management, digital report recapitulation, student assessment, and the interest recommendation module. Sprint 5 wrapped up with integration testing, bug fixing, production deployment, and user training for Admin and Teacher roles. Each stage was performed iteratively in the form of sprints, allowing the results of each phase to be evaluated and refined in subsequent stages [15].

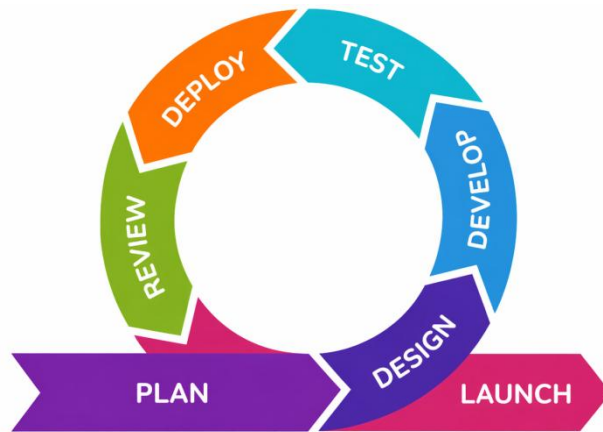


Figure 1. Agile Methodology Process

The Agile stages applied in this study are as follows:

a) Planning

Before any code was written, the team spent time at BKB PAUD Bougenville observing how teachers and administrative staff went about their daily work. Interviews were conducted to identify recurring problems: where data got lost, which reporting tasks took the most time, and what kinds of information teachers wished they had easier access to [16]. These observations produced a set of functional requirements (student data management, attendance recording, developmental assessment, learning material management, and financial administration) as well as non-functional requirements (data security, usability, and accessibility). All items were logged into a product backlog and ranked by priority to guide each sprint.

b) System Design

The design phase translated the backlog items into technical specifications. This included defining how the web application's components would connect to one another [17], structuring the database so that student records, attendance logs, assessment scores, and financial data could all be managed from a single source, and mapping out the workflows that teachers and administrators would follow. Interface mockups were drafted with an emphasis on simplicity, since the primary users PAUD teachers and staff do not have technical backgrounds. The design also included a student interest recommendation system alongside e-learning features within a unified platform. The system uses Agglomerative Hierarchical Clustering with Manhattan distance to group students across six developmental aspects from Permendikbud No. 137/2014 [10], namely: values and religion, physical-motor, cognitive, language, social-emotional, and artistic development. Each aspect is rated on a 1–4 Likert scale. The Silhouette Score determines the optimal cluster count, and the system generates learning recommendations tailored to each group's developmental profile.

c) Development

Code was written incrementally, following the priority order in the backlog for each sprint [18]. Features were built as separate modules student data first, then attendance, then assessment, followed by e-learning and the recommendation engine so that each piece could be tested on its own before being wired into the rest of the system. This modular approach made it easier to catch errors early and kept the overall codebase manageable as it grew.

d) Testing

Every sprint included a testing phase where completed modules were checked against their specifications [19]. Functional tests verified that features worked as intended (for example, that a student attendance record saved correctly and appeared in the right report). Usability tests checked whether teachers could actually navigate the interface without getting stuck. Any issues found during testing were logged and addressed either within the same sprint or at the start of the next one.

e) Deployment

Once a sprint's features passed testing, they were deployed to the live environment at BKB PAUD Bougenville. Staff began using the new features in their actual daily work — entering real student data, recording real attendance, uploading real learning materials [20]. This meant the system was tested against real conditions, not just simulated ones.

f) Evaluation

After each deployment, the team collected feedback from teachers and administrative staff on what worked well and what needed improvement [21]. This feedback loop shaped the backlog for the following sprint, ensuring that each iteration brought the system closer to what users actually needed rather than what had been assumed at the start.

3. Result and Discussions

This section presents the results of the system development and discusses the findings obtained from its implementation. The developed system addresses several operational problems previously identified at BKB PAUD Bougenville. Prior to system deployment, student records, attendance data, and assessment reports were managed separately using paper-based documents and spreadsheet files, resulting in data duplication, reporting delays, and difficulties in information retrieval. By integrating these processes into a centralized database, the system improves data consistency, reduces administrative workload, and enables more efficient access to academic and administrative information.

These findings are consistent with previous studies that reported improved efficiency and information accessibility through web-based educational information systems [3][4]. However, unlike previous studies that focused solely on academic administration or e-learning, the proposed system integrates academic management, administrative services, e-learning, and student interest recommendation features within a single platform. The following sections present the system design, implementation results, and evaluation outcomes to assess the system's functionality and practical contributions.

3.1. System Design

The Use Case Diagram in Figure 2 maps out who uses the system and what they can do with it. Three types of users interact with the platform: Admin, Teacher, and Public. The Admin handles back-office tasks managing student records, teacher assignments, class groupings, financial entries, and system-wide reports. Teachers work with the system on a daily basis to log attendance, enter assessment scores, and access learning-related features. Public users can only view general information such as the institution's profile and downloadable e-book materials.

To make sure the diagram reflected actual practice rather than assumptions, the team worked directly with BKB PAUD Bougenville's teachers and administrative staff during the design phase. Their input shaped which functions were assigned to which role and confirmed that the planned workflows matched how staff already organized their tasks.

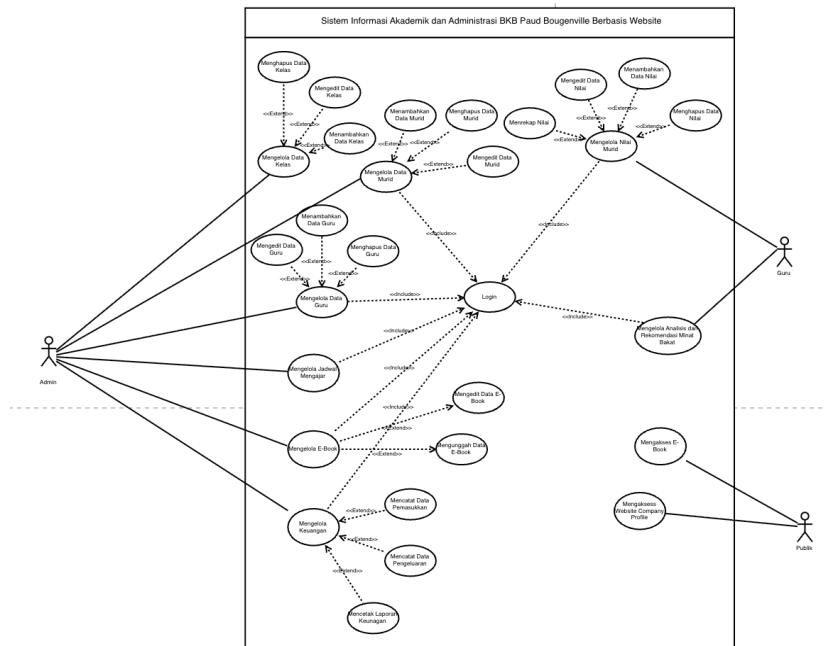


Figure 2. Use Case Diagram

3.2. Activity Diagram

The Activity Diagram illustrates the workflow of system processes within the web-based academic and administrative information system developed for BKB PAUD Bougenville. This diagram is used to describe the sequence of activities performed by system actors and the corresponding system responses.

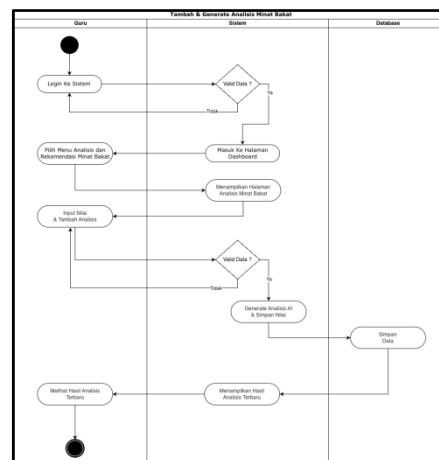


Figure 3. Activity Diagram Interest Recommendation

As shown in Figure 3, the activity diagram illustrates the workflow of the student interest recommendation feature. The process begins with teacher authentication and continues with student assessment data submission, which is validated before analysis. The validated data is then processed by the recommendation module to generate student interest recommendations based on developmental assessment results.

This workflow ensures that recommendation results are generated from verified data and stored systematically within the database. By integrating recommendation processing into the academic information system, teachers can access student development insights more efficiently without requiring separate analytical tools. This integration supports data-driven educational decision-making and facilitates more structured monitoring of student development.

3.3. Entity Relationship Diagram (ERD)

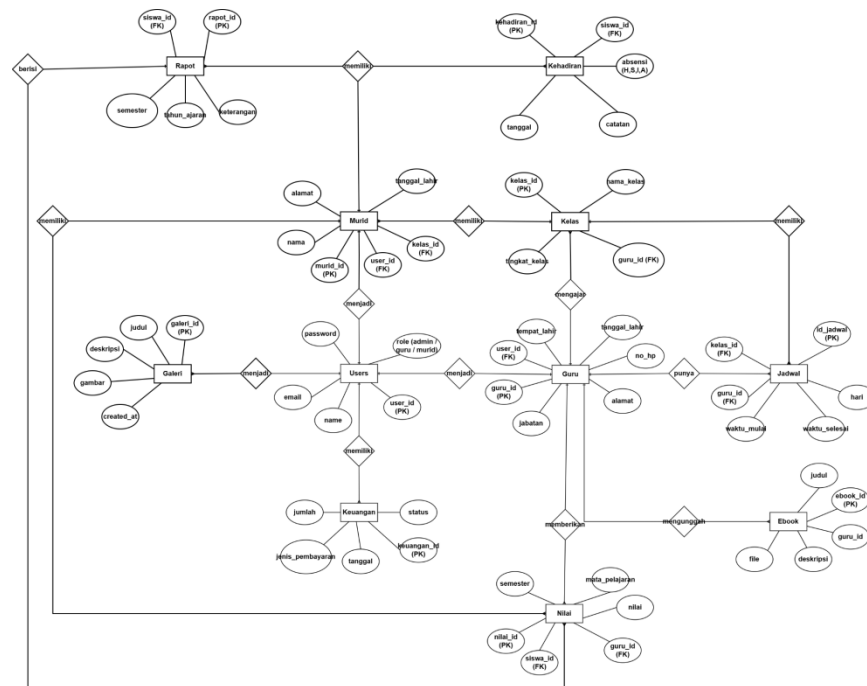


Figure 4. ERD

Figure 4 shows how the database is organized. The central entity is Users, which controls login credentials and role-based access for Admin, Teacher, and Public accounts. Students are linked to Classes (one class per student), and Teachers are also tied to Classes to reflect their teaching assignments.

Assessment data lives in the Grades entity, connected to both Students and Teachers so that each score can be traced back to who entered it and for whom. Attendance records store daily presence status per student. Reports aggregate assessment data by semester and academic year for end-of-period summaries. Schedules hold class timetables with time slots and assigned teachers. E-books store uploaded learning materials, and the Gallery entity holds institutional documentation such as event photos.

The Finance entity tracks payments recording the type, amount, date, and status of each transaction. All entities are connected through foreign keys, so the database enforces referential integrity and prevents orphaned records. This design means that a single student's attendance, grades, reports, and financial status can all be pulled from one place without cross-referencing separate files.

3.4. Interface Design

The interface design in this study aims to support academic and administrative processes within the PAUD environment by emphasizing usability, clarity, and structured navigation. The design focuses on simplifying user interactions, particularly for teachers and administrative staff who may not have a technical background. Therefore, the system adopts a clean layout, consistent visual elements, and intuitive navigation to ensure ease of use in daily operations.

The interface is structured based on the main user workflows, including attendance management, e-learning activities, student assessment, and interest recommendation features. Each component is designed to reflect real operational needs, allowing users to perform tasks efficiently with minimal complexity. In addition, the interface supports structured data input and clear information presentation, enabling users to manage and monitor data effectively.

Figure 5. Student Assessment Form

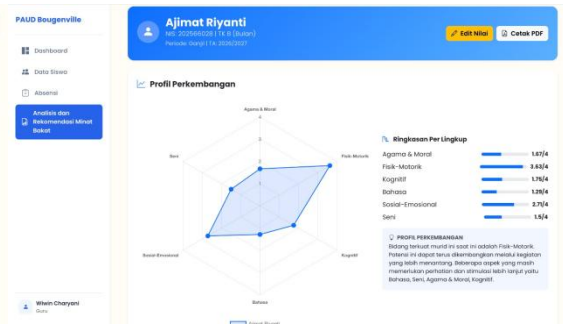


Figure 6. Student Interest Recommendation Result

Figure 5 presents the student assessment form used by teachers to record developmental assessment data in a structured format. The assessment covers six developmental domains defined in Permendikbud No. 137/2014 [10], ensuring that student development data is collected systematically and consistently for further analysis.

Table 1. Silhouette Score Comparison Across k Values

Number of Clusters (k)	Silhouette Score	Cluster Cohesion
3	0.6808	Moderate
4	0.7775	Strong
5	0.8291	Strong (selected)
6	0.7613	Strong

Figure 6 shows the student interest recommendation results for TK B, based on assessment data across six developmental aspects. The system tested $k = 3$ through $k = 6$ using Agglomerative Hierarchical Clustering with Manhattan distance; the scores for each value are listed in Table 1. $k = 5$ gave the highest Silhouette Score of 0.8291, a strong result that points to clear separation between clusters and high within-cluster consistency. The classroom teacher reviewed the outputs and confirmed they matched the students' observed developmental profiles and the indicators in Permendikbud No. 137/2014 [10]. This gives the recommendation feature reasonable credibility as a tool for tracking development and informing learning activity decisions.

3.5 System Implementation and Testing

The development of the integrated web-based academic and administrative information system successfully produced functional modules that support student data management, attendance recording, e-learning activities, student assessment, and interest recommendation processes. To evaluate system quality and reliability, functional and non-functional testing was conducted. The evaluation aimed to determine whether each feature operated according to the specified requirements and whether the system met the quality standards required for practical use within the PAUD environment.

The testing process in this study applies black-box testing with a functional testing approach to evaluate whether each system feature operates according to the specified requirements. In addition, Equivalence Partitioning is used to categorize input data into valid and invalid classes, while Boundary Value Analysis is applied to test input limits such as empty or incomplete data. This combination ensures that the system can handle various input conditions effectively.

The Student Data Input feature enables administrators and teachers to input and manage student data in a structured and efficient manner. The system applies validation mechanisms to ensure that all required fields are properly completed before the data is stored in the database. This reduces the risk of data inconsistency

and improves the accuracy of student records compared to manual data management. In addition, the interface design simplifies the data entry process, allowing users to input information more efficiently.

To evaluate the functionality of this feature, Black Box testing was conducted, and the results are presented in Table 2.

Table 2. Black Box Testing of the Student Data Input Feature

No	Test Scenario	Test Data	Expected Result	Output	Result
1	Input valid student data	Complete and correct student data	Data successfully stored in database	Data saved correctly	Valid
2	Empty required fields	Some fields left blank	System displays validation warning	Warning message displayed	Valid
3	Invalid data format	Incorrect input format	System rejects input	Error message displayed	Valid
4	Edit student data	Modify existing data	Updated data saved correctly	Data updated successfully	Valid

The results indicate that the Student Data Input feature functions properly, as the system is able to validate, process, and store data accurately according to the specified requirements.

The E-Book Management feature supports digital learning activities by providing a centralized platform for managing learning materials. Through this feature, administrators can upload, update, and delete e-book files in a structured manner. This significantly improves accessibility to learning resources and enhances flexibility in the learning process. The testing results for this feature are presented in Table 3.

Table 3. Black Box Testing of the E-Book Management Feature

No	Test Scenario	Test Data	Expected Result	Output	Result
1	Upload valid e-book file	Supported file format (PNG, JPG, JPEG, WEBP)	File successfully uploaded	File stored and displayed	Valid
2	Upload invalid file format	Unsupported file type	System rejects upload	Error notification displayed	Valid
3	Update e-book data	Modify file information	Updated data saved correctly	Data updated successfully	Valid
4	Delete e-book	Select and delete file	File removed from system	File deleted successfully	Valid

Based on the testing results, the E-Book Management feature operates effectively in handling file management processes and ensures that only valid data is processed by the system. Meanwhile, the Student Assessment Form Figure 11 allows teachers to record student developmental data in a structured format. The system ensures that all required data is validated before submission, and the recorded data is stored systematically for further analysis, including generating student interest recommendations. The testing results for this feature are shown in Table 4.

Table 4. Black Box Testing Student Assessment Form Figure 11

No	Test Scenario	Test Data	Expected Result	Output	Result
1	Input complete assessment data	All fields filled correctly	Data successfully recorded	Data stored correctly	Valid
2	Incomplete form submission	Missing required fields	System displays validation warning	Warning message displayed	Valid
3	Submit assessment data	Valid submission	System processes and saves data	Assessment recorded successfully	Valid
4	Input invalid data	Incorrect format input	System rejects input	Error message displayed	Valid

The testing results show that the Student Assessment Form feature functions correctly in validating, processing, and storing assessment data. This ensures that the system can support structured and reliable student evaluation processes.

Overall, the Black Box testing results indicate that all evaluated features function according to the specified requirements and successfully handle both valid and invalid input conditions. The successful execution of student data management, e-learning, and assessment functionalities demonstrates that the system can support daily academic and administrative activities reliably. These results suggest that the integration of multiple services within a single platform reduces the complexity of information management and minimizes the risk of data inconsistency commonly encountered in manual processes. The system is capable of handling user input, processing data, and generating outputs without errors, demonstrating its functional reliability.

From an analytical perspective, the implementation of this system provides several improvements compared to conventional manual methods. First, data management becomes more efficient due to centralized storage and automated validation processes. Second, the integration of e-learning features enhances accessibility and flexibility in managing learning materials. Third, the digital assessment system enables more accurate and structured evaluation of student development.

In addition to functional testing, non-functional testing was also conducted to evaluate the system quality in terms of usability, performance, compatibility, security, reliability, and accessibility. The results of non-functional testing are presented in Table 5.

Table 5. Non-Functional Testing

No	Testing Aspect	Test Scenario	Expected Result	Output	Result
1	Usability	Users navigate menus and main features	System is easy to use and understand	Users can operate the system without difficulty	Valid
2	Performance	Access dashboard and input data	Pages load quickly	System response is fast and stable	Valid
3	Compatibility	Access system using different browsers (Chrome, Edge)	System runs properly on all browsers	System operates without errors	Valid

No	Testing Aspect	Test Scenario	Expected Result	Output	Result
4	Security	Login using incorrect credentials	System rejects access and shows error	Access denied and error message displayed	Valid
5	Reliability	Repeated data input and storage	System remains stable without errors	Data stored consistently	Valid
6	Accessibility	System accessed by multiple users	System remains accessible and functional	No access issues occur	Valid

Based on the results shown in Table 5, the system demonstrates good performance across multiple quality aspects. The system is easy to use, provides fast response times, is compatible across different browsers, and maintains security and stability during operation. These results indicate that the system not only functions correctly from a technical perspective but also meets the quality requirements for practical implementation within the PAUD environment.

In addition to functional and non-functional testing, a usability evaluation was conducted using the System Usability Scale (SUS), a standardized and validated instrument widely used to assess the usability of information systems. The evaluation involved eight respondents, consisting of seven teachers and one administrative staff member from BKB PAUD Bougenville. Since the developed system was specifically designed for use within the institution, all active users were included in the usability assessment.

As presented in Table 6, the developed system achieved an average SUS score of 84.4 out of 100. Based on the SUS interpretation scale, this score falls within Grade A and the Excellent category, indicating a high level of usability and user acceptance. The results suggest that users found the system easy to learn, easy to operate, and effective in supporting academic and administrative activities.

Table 6. System Usability Scale (SUS) Evaluation Results

Respondent	SUS Score
R1	85.0
R2	82.5
R3	87.5
R4	80.0
R5	90.0
R6	82.5
R7	85.0
R8	83.0
Average SUS Score	84.4
Category	Excellent (Grade A)

These findings indicate that the developed system not only satisfies functional requirements but also provides a positive user experience. Therefore, the system is considered suitable for implementation within the PAUD environment and can effectively support daily operational processes.

The implementation of the integrated academic and administrative information system successfully addressed several operational challenges previously encountered at BKB PAUD Bougenville. The findings of this study are consistent with previous research showing that web-based information systems improve data management efficiency, enhance information accessibility, and reduce administrative complexity within educational institutions [3], [4]. Similar benefits were observed in this study, where centralized database management reduced data duplication, accelerated information retrieval, and improved the consistency of academic and administrative records.

However, this study differs from previous works in terms of system scope and integration. Previous studies have primarily focused on improving educational administration and institutional efficiency through web-based information systems [3], [4]. In contrast, the proposed system integrates student data management, attendance recording, developmental assessment, e-learning services, and administrative management within a single platform. Compared with existing platforms developed for higher education environments, the proposed system is specifically designed for Early Childhood Education (ECE) institutions and incorporates features tailored to the operational and developmental monitoring needs of young learners [6].

This study also extends previous research on educational data analysis and student profiling. Previous research has demonstrated the potential of machine learning techniques for monitoring child development and identifying developmental characteristics [8]. Similarly, this study utilizes Agglomerative Hierarchical Clustering to analyze developmental assessment data based on the six developmental domains defined in Permendikbud No. 137 Tahun 2014. Although previous studies have applied machine learning to monitor child development and identify developmental characteristics [8], the present study extends this approach by directly integrating clustering results into the academic information system to generate student interest recommendations for supporting learning planning and student development monitoring.

The usability evaluation results further indicate that the developed system was positively received by teachers and administrative staff. The average SUS score of 84.4 places the system within the Excellent category, indicating a high level of usability and user acceptance. These findings suggest that the integrated platform not only improves operational efficiency but also supports data-driven educational decision-making. Therefore, the study contributes to the literature by demonstrating how administrative management, educational services, and recommendation-based analytics can be combined within a single integrated platform for Early Childhood Education institutions.

4. Conclusions and Future Works

Based on the results of this study, a web-based academic and administrative information system integrated with e-learning and student interest recommendation features was successfully developed and implemented at BKB PAUD Bougenville. The application of the Agile methodology facilitated iterative system development and enabled continuous adaptation to user requirements throughout the development process.

The developed system integrates several key functionalities, including student data management, attendance recording, developmental assessment, e-learning services, financial administration, and student interest recommendation features within a single platform. The integration of these functionalities provides a structured approach to managing academic and administrative activities while supporting teachers in accessing student development information more efficiently.

The findings indicate that the proposed system is feasible for supporting digital transformation initiatives within the studied institution and shows potential to enhance the management of educational information and services. However, since the study was conducted in a single early childhood education institution and did not include a rigorous comparative effectiveness evaluation, the results should be interpreted as evidence of implementation feasibility rather than definitive proof of effectiveness across broader educational contexts. Future research should involve multiple institutions and more comprehensive evaluation methods to assess system effectiveness, usability, and long-term impact in diverse educational environments.

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