Journal of Electrical Engineering and Computer (JEECOM)
Vol. 7, No. 2 (2025), DOI: 10.33650/jeecom.v7i2.12706
p-ISSN: 2715-0410; e-ISSN: 2715-6427

Design and Evaluation of a Web-Based Geographic Information System for PPDB Promotion Zoning Based on Student-Origin Distributions

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Article Info

Article history:

Received Okt 9, 2025
Revised Okt 15, 2025
Accepted Okt 21, 2025

Keywords:

PPDB
web-based GIS
promotion zoning
distance buffer
Leaflet

ABSTRACT

Advances in information technology have accelerated the digitalization of educational services, including Indonesia's student admission process (PPDB). This study designs and evaluates a web-based Geographic Information System (GIS) to map student-origin distributions and construct promotion zones that guide PPDB outreach strategies. The system was built with CodeIgniter and Leaflet for interactive mapping, while applicant addresses/school origins were processed via geocoding. Outputs include point maps, density heatmaps, administrative-area aggregation (urban village/sub-district), and simple distance buffers (e.g., 1–3 km) to derive rule-based priority promotion zones (thresholds on density and proximity to the school). Evaluation comprised functional testing (black box) and user assessments using questionnaires (Likert/SUS). Results indicate that the system expedites registration, reduces the risk of data loss, simplifies data summarization, and provides promotion-zoning maps that help committees target outreach more effectively. The contributions are: (1) a PPDB web-GIS model that combines origin mapping with rule-based promotion zoning, (2) a replicable operational workflow, and (3) recommendations for future work, including advanced analytics dashboards and automated notifications.

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1. INTRODUCTION

The digital transformation in education requires institutions to modernize student admission services (Penerimaan Peserta Didik Baru / PPDB) while ensuring that management decision-making is supported by reliable data. However, in many schools, PPDB workflows still face several challenges, such as repetitive form filling, error-prone document handling, manual recapitulation, and fragmented data storage. More importantly, existing systems provide little to no capability to analyze the spatial distribution of prospective students, even though the effectiveness of promotional and outreach activities heavily depends on the geographic patterns of feeder schools and applicants' addresses. Existing web-based PPDB applications generally focus on digitizing administrative processes using the Model–View–Controller (MVC) framework [1], [11], [14], [25].

Although such approaches improve efficiency and reduce paper-based administration, they remain inadequate for strategic planning. Traditional MVC systems treat addresses merely as plain text fields, without the ability to map, measure, or visualize spatial relationships. As a result, admission committees are unable to identify areas with high applicant concentrations, detect underrepresented regions, or plan evidence-based promotional strategies. Moreover, current PPDB guidelines emphasize procedural aspects rather than providing analytical tools for data-driven outreach planning [9].

Web-based Geographic Information Systems (GIS) offer an effective and accessible way to visualize and interpret spatial information at an institutional scale. Previous studies employing Leaflet or PostGIS have demonstrated that web-GIS solutions can enhance transparency and planning effectiveness within the public sector [2], [13], [17], [26]. However, most of these systems focus only on thematic mapping—such as business location maps, school directories, or government asset inventories—without extending their capabilities to

operational decision-making, such as PPDB promotion zoning. Meanwhile, database-oriented research has explored entity-relationship modeling and address data management that support data integrity in admissions [20], [22]; yet such approaches rarely translate into practical zoning strategies or rule-based decision mechanisms. These limitations highlight the need for developing a lightweight rule-based GIS approach that can be integrated into existing school web infrastructures to generate spatial insights that are easily interpretable by admission committees.

To address this gap, this study proposes a web-based GIS system that integrates online registration data with spatial analysis tools to visualize student-origin distributions and automatically generate promotion zones. The developed system transforms textual addresses into spatial coordinates through a geocoding process, aggregates the data by administrative areas (urban village or sub-district), and applies simple straight-line distance calculations (e.g., within a 1–3 km radius) to define potential outreach regions. These spatial indicators are then combined using a rule-based mechanism that classifies each area into high, medium, or low promotion priority according to applicant density and proximity to the school. The system architecture is implemented using the CodeIgniter framework and the Leaflet library, both of which are widely adopted in educational and geospatial applications [5], [13], [17]. The development process follows an R&D (Research and Development) model [3] and adheres to robust database design principles [20], [28] to ensure data consistency, integrity, and replicability.

2. METHOD

This study employs an applied Research and Development (R&D) approach combined with a conventional waterfall model, which consists of four main stages: requirement analysis, design, implementation, and testing. The R&D approach was chosen to ensure that each development stage can be systematically traced and replicated, while the waterfall model provides a clear workflow from problem identification to system evaluation. The overall research procedure is illustrated in Figure 1, summarizing the major phases from requirement identification to system evaluation.

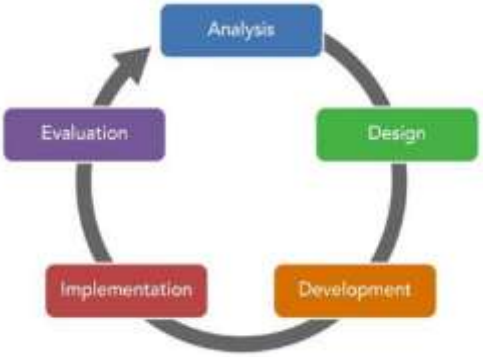


Figure 1. Research and Development (R&D) Model

The requirement analysis phase was conducted through short interviews and direct observation of PPDB activities in schools to identify operational constraints and user needs. This stage was complemented by a literature review focusing on web-based PPDB systems and web-based Geographic Information Systems (GIS). The outputs include both functional and non-functional requirements, such as data privacy and integrity specifications.

In the design phase, the system architecture was modeled using the Model–View–Controller (MVC) pattern. The CodeIgniter framework was used for the backend, while Leaflet was employed as the mapping library for the interactive GIS interface. Supporting artifacts such as the Entity–Relationship Diagram (ERD), Data Flow Diagram (DFD), and system flowchart were developed to ensure logical consistency among data storage, processing, and visualization layers [20].

The implementation phase was conducted in a LAMP (Linux, Apache, MySQL, PHP) environment. This implementation integrates online registration, verification, and GIS-based mapping modules into a single unified platform. The database design was normalized to maintain relational integrity and support analytical queries related to applicant origins and spatial aggregation [20].

The testing and evaluation phase consisted of three components: (1) functional testing using the black-box method to verify core functionalities such as registration, verification, reporting, and mapping [25]; (2) performance testing measuring map and layer load times using Time-to-First-Byte (TTFB) and full-render metrics [5]; and (3) user satisfaction testing through a Likert or System Usability Scale (SUS) questionnaire

ISSN: 2715-6427

assessing ease of use, interface clarity, perceived usefulness, and overall satisfaction [10]. Results were summarized using median and interquartile range statistics.

Overall, this methodological framework ensures that the PPDB Web-GIS system was developed in a structured, traceable, and scientifically valid manner, effectively transforming student-origin data into rule-based promotion zones that support operational decision-making at the school level.

3. RESULTS AND DISCUSSION

Prior studies broadly indicate that web-based PPDB information systems can streamline admissions by simplifying form handling, validation, and reporting within familiar MVC workflows. Similarly, integrating a web-GIS component improves the clarity of applicant-origin visualization and makes zoning analyses more objective and transparent for planning. In practice, the waterfall model is often preferred because its structured, sequential stages align well with projects whose requirements remain relatively stable during development and demand clear documentation. From a technology standpoint, a lightweight stack—CodeIgniter for the backend and Leaflet for interactive mapping—reduces deployment and maintenance overhead on typical school infrastructure. Building on these insights, this work implements a rule-based promotion-zoning approach that combines density quantiles at the administrative-area level with simple straight-line distance buffers around the school. The result is a set of interpretable High/Medium/Low priority labels that translate spatial evidence into actionable guidance for outreach planning, extending common PPDB digitization practices with practical geospatial decision support while avoiding specialized clustering or network-distance dependencies.

3.1. Analysis and design

The analysis and design stages were conducted after collecting data through interviews, observation, and a literature scan. In these stages, we identified system requirements, outlined process flows, and modeled the underlying data and information. The requirements analysis produced a concise specification of core features, including online registration, administrator verification, publication of selection results, and interactive mapping of student domicile data to support promotion zoning. The design work translated these requirements into visual and formal artifacts: a system flowchart describing end-to-end user and administrator workflows, a Data Flow Diagram (DFD) mapping data movement across processes, external entities, and data stores, and a corresponding logical data model to ensure integrity and reporting readiness. These analysis and design outputs serve as the primary blueprint for subsequent implementation and testing activities.

3.1.1. Data Flow Diagram (DFD)

The context diagram models the PPDB Web-GIS as a single, central process interacting with two external entities: Applicants and the Admin (Committee). Applicants send registration data, uploaded documents, and profile updates to the system, while the system returns application status, announcements, and an interactive map that visualizes student origins for promotion zoning. The Admin provides verification and admission decisions, maintains master data and content, and configures threshold/zone settings; in return, the system delivers applicant lists, reports and statistics, zoning summaries (High/Medium/Low), and export/audit outputs. This context view establishes the primary data exchanges that guide subsequent decomposition of processes and data stores.

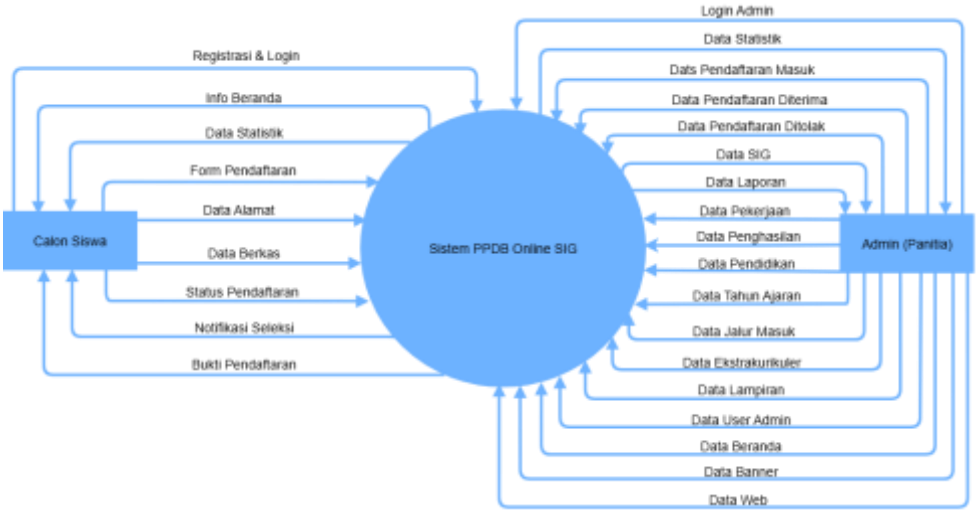


Figure 2. Context diagram models the PPDB Web-GIS

3.1.2. Subsub section 2

The Entity Relationship Diagram (ERD) of the PPDB Web-GIS system describes how core operational entities, master references, and spatial data are linked across online registration, student-data management, and GIS-based mapping. Together, these relationships ensure data integrity for admissions, enable reusable master data, and provide a clean join path from applicant records to spatial aggregation for promotion-zoning maps.

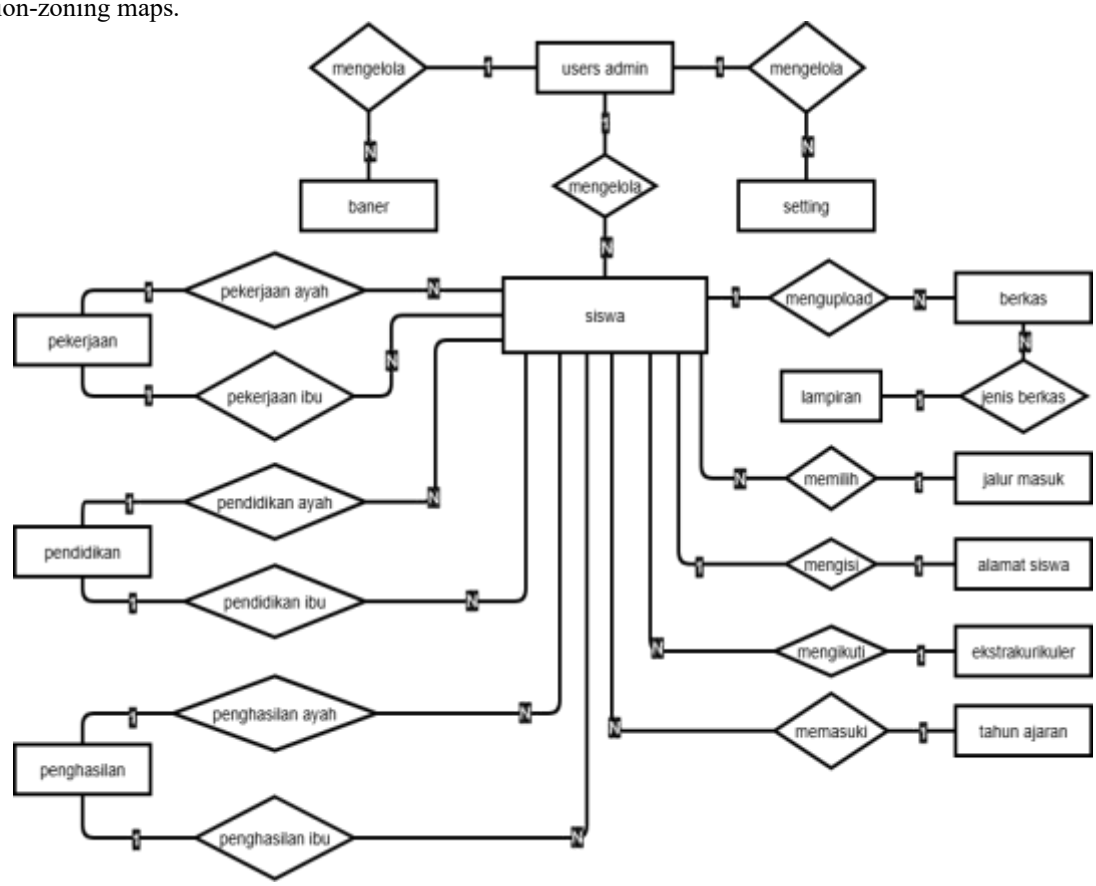


Figure 3. Entity Relationship Diagram (ERD) of the PPDB Web-GIS

3.2. Implementation

Following the design phase, the system was implemented on an MVC stack (CodeIgniter for the backend/API, MySQL for data persistence, and Leaflet for interactive maps) and deployed on a standard LAMP environment. The public interface comprises a landing page with school information and announcements, an online registration form that captures applicant identity and domicile/feeder-school data, an upload module for required documents, and an applicant login to track application status and view announcements. The administrative interface provides an authentication-protected dashboard showing key admission statistics by academic year, menus for verifying and deciding applications (accept/reject/delete), master-data management (jobs, income, education, academic year, admission track, extracurriculars, document types, users), and content configuration (homepage text and banner/slider).

Figure 4 shows the implementation of the online PPDB registration interface for the 2025/2026 academic year. The interface is designed with a clean and responsive layout that adheres to the principles of user-centered design. The registration form includes key input fields such as NISN, full name, nickname, place and date of birth, gender, and admission pathway. A validation mechanism is applied to ensure that all required fields are properly completed before data submission.

ISSN: 2715-6427



Figure 4. Registration and Login Page

Figure 5 shows the registration form interface used to input applicant data, including registration details, a 3×4 photo, personal identity, home address, parental information, previous school, and supporting documents. The address entry section integrates a GIS-based mapping feature built with Leaflet.js, which displays maps from OpenStreetMap. When the address modal is opened, the system automatically activates the device's GPS to detect the applicant's current location. Users can also click the Detect My Location button to manually trigger geolocation. Once coordinates are obtained, the reverse geocoding function from Nominatim automatically updates both the map view and the address input field. The map marker can be dragged to fine-tune the position, and any marker movement instantly updates the address data on the form. An address search bar is also provided to help users locate specific places efficiently.

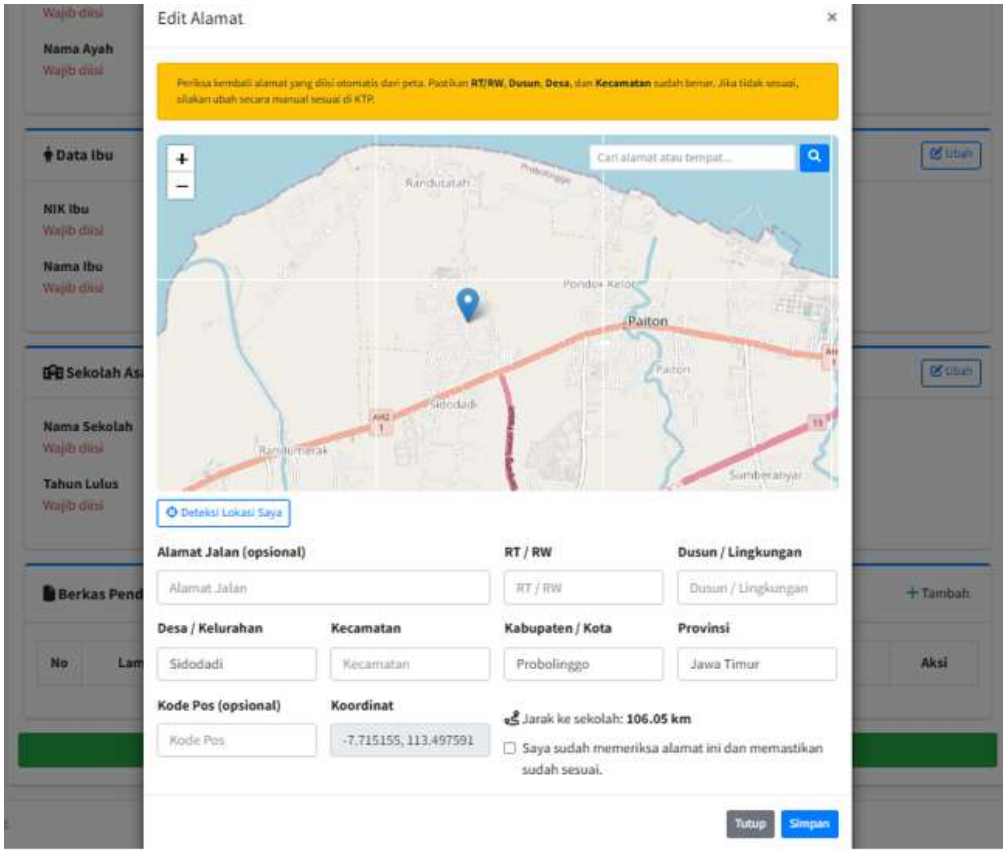


Figure 5. Online registration and input applicant data page

This page presents admissions statistics by academic year in a clear, interactive view. At the top, a line chart shows trends for male, female, and total applicants per year. Directly below is an academic-year filter (default: latest year) that refreshes all visuals. The next section includes summary KPI cards (total applicants, male, female, accepted/rejected), a pie chart (gender/selection composition), a bar chart (applicants by sub-district/urban village or feeder school), and a GIS heatmap highlighting major/minor origin areas. All visuals pull live data from the applicant database and student master records, updating automatically with the selected year.

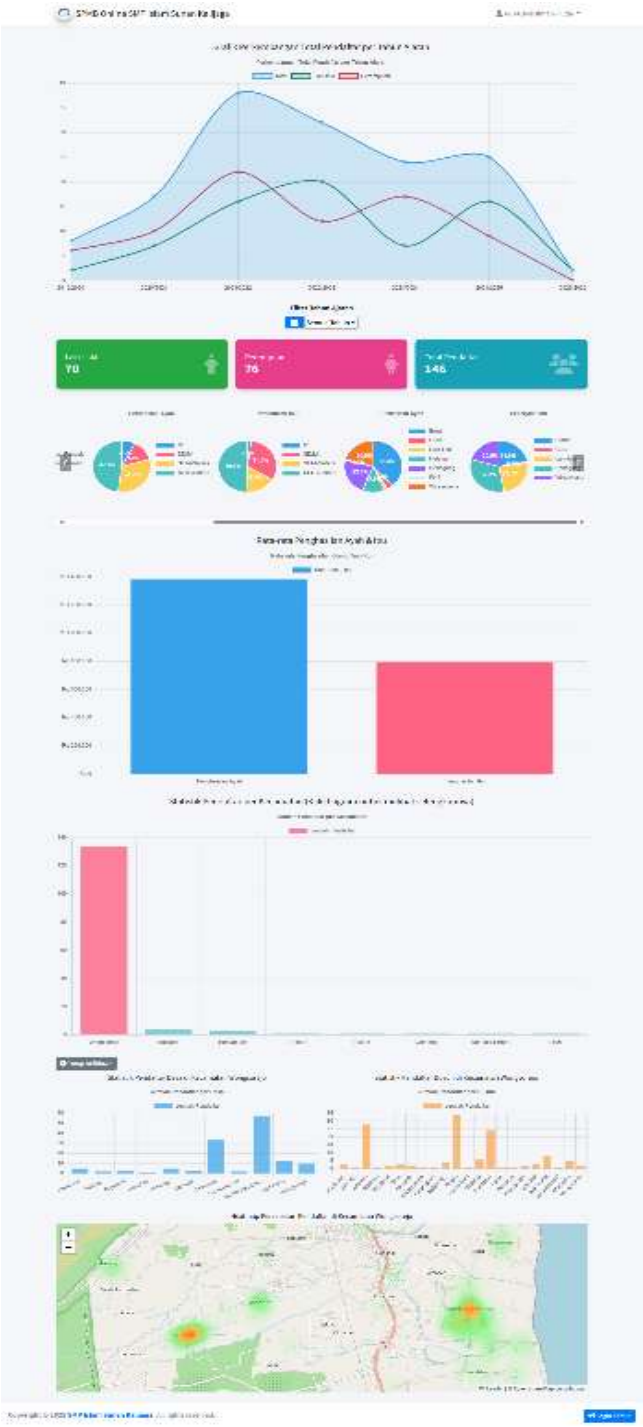


Figure 6. Presents Admissions Statistics Page

ISSN: 2715-6427

3.3. Testing Results

External testing was conducted on 30 respondents, consisting of students and school staff as end users. This testing aimed to evaluate usability, interface clarity, feature effectiveness, and overall user satisfaction toward the developed Web-GIS–based PPDB system. 5-point Likert scale was used with the following weights:

A = 5 (Strongly Agree),
B = 4 (Agree),
C = 3 (Neutral),
D = 2 (Disagree),
E = 1 (Strongly Disagree).

Respondents answered ten key questions covering aspects of usability, visual clarity, functional accuracy, system reliability, and overall user experience.

The overall results show a total score of 1,350 out of a possible 1,500 points (30 respondents × 10 questions × maximum score 5). Based on the calculation, the system acceptance rate is 90.0%, which falls into the "Excellent" category according to the evaluation interval shown in Table 1.

Table 1. The category evaluation interval

Score Range	Category
0% – 19.9%	Very Poor
20% – 39.9%	Poor
40% – 59.9%	Neutral
60% – 79.9%	Good
80% – 100%	Excellent

Based on the external testing results, it can be concluded that the developed Web-GIS PPDB system meets the criteria of functionality, usability, and interface clarity at an excellent level. Respondents expressed particularly positive feedback on the ease of filling out the registration form and the intuitiveness of the interactive map interface powered by Leaflet. These findings indicate that the system is ready for practical implementation to support an efficient and data-driven student admission process in schools.

4. CONCLUSION

The developed Web-GIS–based PPDB system has successfully implemented all its core modules. User testing involving 30 respondents (comprising students and school staff) produced a system acceptance rate of 90.0%, which falls into the "Excellent" category based on the Likert evaluation scale. The majority of respondents agreed that the system is easy to use, features a clear interface, and that the GIS mapping component greatly assists in understanding the geographic distribution of applicants. These quantitative results confirm that the developed system is technically feasible, operationally reliable, and well accepted by users.

Based on these findings, this research provides clear directions for further development. In the short term, improvements will focus on standardizing address inputs, refining data-cleaning rules, implementing cache and tiling mechanisms to accelerate map rendering, and expanding analytical dashboards for annual trend monitoring. In the medium term, the system will be enhanced through integration of network-based proximity analysis, the inclusion of additional administrative indicators such as feeder-school conversion ratios, and the development of automated analytical reports for PPDB committees. In the long term, the system can be extended to support broader educational planning tasks, such as scholarship zoning, student transportation route planning, and school capacity analysis at the district or provincial level.

Overall, this system demonstrates a quantitatively validated contribution to the implementation of spatial decision support systems in educational management. Upholding the principles of transparency, accessibility, and data-driven decision-making, the outcomes of this study support the realization of an effective digital transformation in the student admission (PPDB) process.

ACKNOWLEDGEMENTS

The author expresses sincere gratitude to the school administration, teachers, and students who participated in the system testing and provided valuable feedback throughout the research process. Special appreciation is also extended to the Department of Education and the IT staff of the partner school for their

collaboration, technical assistance, and insights that greatly supported the development and evaluation of the Web-GIS–based PPDB system.

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