



EDUTRACE: A Web Based Early Warning System for Detecting Out-of-School Children in Tasikmalaya

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Abstract - The problem of out-of-school children (OTS) is one of the most persistent challenges in the Indonesian education system. Tasikmalaya Regency recorded 29,949 children aged 7–18 years who were not receiving education as of October 2025, while West Java reported 658,831 OTS, the highest absolute figure nationally. The persistence of this problem is caused by three systemic gaps: fragmentation between the Dapodik (Ministry of Education and Culture) and EMIS (Ministry of Religious Affairs) data systems, the absence of an early warning mechanism to identify at-risk students before they drop out, and the unregistered status of thousands of salafiyah Islamic boarding schools (pesantren) whose students are incorrectly classified as OTS. This paper presents the design and development of a prototype of EDUTRACE (Education Tracking and Early Alert System), a web-based information system developed using React, TypeScript, Vite, and Tailwind CSS. The system integrates data from various educational registries, provides a machine learning-based risk assessment mechanism for early identification of at-risk students, and automates notification to stakeholders. The research used a literature review methodology combined with prototype development, without formal usability testing. The resulting prototype demonstrates the feasibility of a data-driven, preventive approach to addressing ATS in a local government context. EDUTRACE contributes to the achievement of SDG 4 (Quality Education), specifically Targets 4.1, 4.5, and 4.6, by enabling earlier and more targeted educational interventions. The system's modular architecture allows for phased implementation across schools, villages, and sub-district education offices.

Keywords : Out-of-school children; early warning system; education information system; machine learning.

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I. INTRODUCTION

Education is a basic right guaranteed by Article 31 paragraph (1) of the 1945 Constitution and strengthened by Law Number 20 of 2003 concerning the National Education System [1]. Despite significant policy attention, the phenomenon of out-of-school children (OTS) continues to persist on a large scale in Indonesia. According to the ATS Verification and Validation Dashboard published by the Ministry of Education, Culture, Research, and Technology's Data Center (Pusdatin), approximately 3.87 million school-age children in Indonesia are not enrolled in any educational institution [2].

At the provincial level, West Java recorded 658,831 ATS in November 2024, the highest absolute figure nationally, consisting of 164,631 cases of school dropouts, 198,570 cases of students who did not continue, and 295,530 children who had never attended school at all [3]. Globally, the UN reports 272 million children and adolescents will be out of school by 2023, confirming that this remains a global challenge that threatens the achievement of SDG 4 [4].

At the district level, Tasikmalaya Regency exhibits a particularly acute caseload. The Data and Information Center (Pusdatin) ATS dashboard, as of October 3, 2025, recorded 29,949 ATS in the regency, prompting the local government to establish a dedicated Task Force for ATS validation and management and to conduct technical guidance for 1,062 school principals in 39 sub-districts [4]. The root causes of this phenomenon are well-documented in the literature. Economic factors have consistently been identified as the strongest predictor of school dropout in Indonesia [5]. BPS 2024 data shows that economic inability to pay school fees was cited by 76% of families as the main reason children dropped out of school [6], [7]. Beyond economic factors, the structural fragmentation of the education data system creates a second layer of dysfunction: data collected through Dapodik by the Ministry of Education and Culture and EMIS by the Ministry of Religious Affairs are not automatically synchronized, resulting in data gaps, duplication, and systemic misclassification [8], [9]. The Smart Indonesia Card (KIP) program, as the government's main instrument, also faces serious targeting challenges [10].

In Tasikmalaya, this problem is exacerbated by the fact that thousands of students from non-formal Salafiyah Islamic boarding schools are not registered in any system, so they are counted as ATS even though they are actively participating in Islamic education [11]. The third critical gap is the lack of a proactive early warning mechanism. Fitriana et al. (2024) achieved a model accuracy of 94.2% and an AUC of 0.948 using attendance rate, academic achievement, and family background as predictors [12]. The implementation of Random Forest with SMOTE for predicting the risk of dropping out of elementary school in Indonesia also achieved 99% accuracy [13]. Pradana et al. (2025) confirmed that Business Intelligence and predictive analytics have become the main tools for preventing school dropouts worldwide [12]. WhatsApp API-based notification system has proven effective as a timely warning mechanism in Indonesian education services [14].

This study proposes and prototypes EDUTRACE (Education Tracking and Early Alert System), a web-based information system to integrate education data across systems, calculate weekly risk scores for active students, and automate notification to stakeholders to enable preventive interventions. Utilization of web-based GIS for mapping ATS distribution [15] become a crucial component in supporting evidence-based decision making [16], [17].

II. MATERIAL AND METHODS

A. Research Design

This research employed a literature review methodology combined with prototype development. The literature review phase involved the systematic collection and analysis of data from primary government sources (BPS, Kemendikbudristek, Disdikbud), peer-reviewed academic journals (SINTA-indexed national journals and Scopus-indexed international journals), and verified news sources. The prototype development phase followed an iterative design process informed by the gap analysis findings.

B. Data Collection

Secondary data were collected from: ATS Dashboard of Pusdatin Kemendikbudristek (accessed October 2025 and July 2025); BPS Education Statistics 2024 (November 2024); official statement of Tasikmalaya Regency Education and Culture Office (November 2025); academic journals indexed by SINTA (national) and Scopus (international), period 2019–2025; and BPS Susenas 2023 data on school participation rates.

C. Gap Analysis Framework.

The gap analysis is structured into five dimensions: (1) data integration gap between Dapodik and EMIS; (2) coverage gap of unregistered non-formal Islamic boarding schools; (3) mechanism gap due to the absence of an early warning system; (4) coordination gap among multi-sector stakeholders; and (5) technical infrastructure gap of village-level digital capacity.

D. Prototype Development

Prototipe dikembangkan menggunakan tumpukan teknologi berikut:

TABLE I

EDUTRACE PROTOTYPE TECHNOLOGY STACK

Component	Technology
Framework Frontend	React 18 + TypeScript
Build Tool	Vite 6
Styling	Tailwind CSS v4
Komponen UI	shaden/ui (Radix UI)
Visualisasi Data	Recharts
Routing	React Router v7
Desain Prototipe	Figma (via Figma Make AI)

The prototype includes six core pages with three different user roles: Disdikbud (full access, district-wide coverage), Principal (limited to own school), and Village Official (limited to own village/sub-district). The implemented modules include: Login (role-based authentication), Dashboard (statistics, trend graphs, GIS maps), Early Warning (ML-based risk detection), Student Data, Islamic Boarding School Registry, Notifications, Analytics, and Reports [17], [18].

III. RESULT AND DISCUSSION

A. ATS Problem Profile in Tasikmalaya Regency

Skala permasalahan ATS di Kabupaten Tasikmalaya bersifat substansial dan multidimensi. Tabel II menyajikan komposisi 29.949 kasus ATS yang tercatat pada Oktober 2025.

TABLE II
ATS COMPOSITION AT TASIKMLAYA REGENCY (OKTOBER 2025)

Category	Amount	Percentage
Belum Pernah Bersekolah (BPB)	9.458	31,58%
Putus Sekolah (DO)	8.821	29,46%
Lulus Tidak Melanjutkan (LTM)	11.670	38,96%
TOTAL	29.949	100%

Source : Dashboard ATS Pusdatin Kemendikbudristek (3 Oktober 2025)

At the provincial level, West Java's 658,831 ATS cases represent the highest absolute number in Indonesia. BPS data (2024) reports that the average length of schooling in West Java is only 8.83 years, below the 9-year compulsory education threshold [3]. This phenomenon is strongly correlated with poverty: cross-regional research in Indonesia consistently identifies economic disadvantage as a major driver of school dropout [6], [7].

B. Systemic Gaps in ATS Management

The gap analysis identified seven critical systemic weaknesses, as summarized in Table III.

TABLE III
GAP ANALYSIS : SISTEMIC WEAKNESS ATS MANAGEMENT

Gap	Current Condition	Impact
Fragmentation Dapodik-EMIS	Two systems running in parallel without automatic synchronization	Duplication of data, distortion of numbers ATS [8], [9]
Exclusion of Non-Formal Islamic Boarding Schools	Thousands of Salafiyah Islamic boarding schools are not registered in Dapodik/EMIS	Active students are counted as ATS [11]

No Early Warning System	There is no data-driven proactive detection mechanism	Intervention only after dropping out of school [12], [19]
Manual Reporting	Paper-based data collection, error-prone	Data is inaccurate and late [19], [20]
No GIS Visualization	No spatial map of ATS distribution is available	The policy is mass, not targeted [15]
Aid Distribution Is Not Targeted	KIP and social assistance do not always reach the highest-risk children.	Public spending is inefficient [10]
Failure of Multi-Sector Coordination	Disdikbud, Kemenag, Dinsos operate in data silos	There is no unified monitoring platform [21]

Source: Disdikbud Kab. Tasikmalaya (2025), Lintas Priangan (2025), dan Yanto & Hamdi (2025)

The fragmentation of Dapodik-EMIS is not a problem exclusive to Tasikmalaya. Yanto and Hamdi (2025) documented identical integration challenges in Muaro Jambi Regency [8], and recent studies confirm the need for consolidated data standards [9]. The issue of exclusion from non-formal Islamic boarding schools is critical in Tasikmalaya. The Deputy Regent of Tasikmalaya openly acknowledged that some of the 29,949 ATS students need to be validated because some are actually actively studying at Salafiyah Islamic boarding schools [22].

C. EDUTRACE Prototype Implementation

EDUTRACE is designed as an integration layer on top of Dapodik, EMIS, and Dukcapil. Figure 1 shows the EDUTRACE login page, which displays three role-based access options: Disdikbud (district level), Principal (school level), and Village Official (village/sub-district level). The page also presents key statistics: 29.9K ATS Tasikmalaya, 658K ATS West Java, and 94% prediction accuracy.

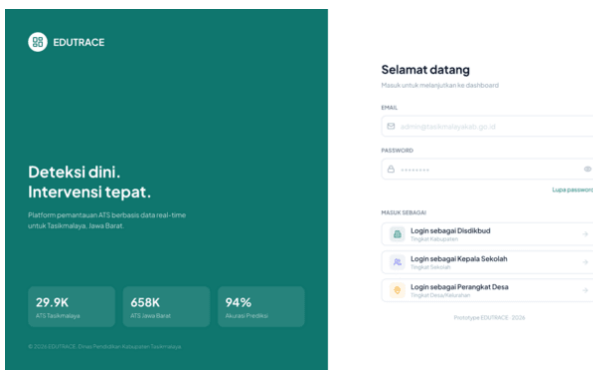


Figure 1. EDUTRACE Login Page with three user role authentication

Figure 2 displays the Disdikbud Dashboard as the primary interface for district-level operators. The dashboard displays four real-time statistics cards (29,949 Total ATS, 1,247 High-Risk Students, 312 Monitored Schools, 87 Registered Islamic Boarding Schools), a six-month ATS trend chart with a positive trend indicator of a 3.8% decrease, a color-coded ATS distribution map per sub-district (High/Medium/Low), a table of sub-districts with the highest ATS, and a real-time system activity feed. The Disdikbud Dashboard also displays the real-time synchronization status of Dapodik and EMIS.

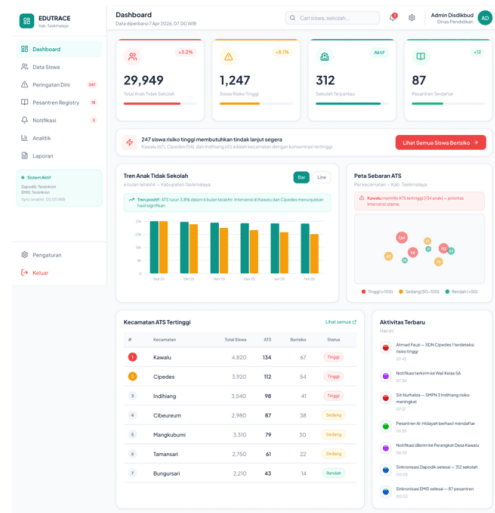


Figure 2. Disdikbud EDUTRACE dashboard: district statistics, ATS trends, and distribution maps per sub-district

Figure 3 displays the Early Warning System module of the Education and Culture Office. This module lists 247 high-risk (Critical) students, 412 moderate-risk (Monitored), 588 low-risk (Safe), and 1,247 students under monitoring. The at-risk student table displays a color-coded risk score (0–100) with a progress bar, risk level, KIP status, and action buttons for Details and CSV Export. Data is updated every Monday from the Dapodik and EMIS synchronization.

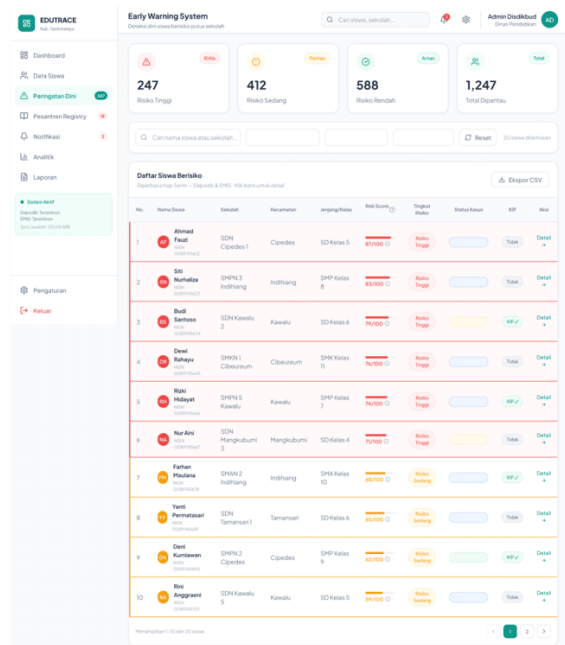


Figure 3. Disdikbud Early Warning Module: ML risk score, risk level, and KIP status per student

Figure 4 displays the Disdikbud Student Data page, which provides a complete list of students with information on their National Identification Number (NIS), school, class, village, attendance percentage, and color-coded risk status. The All/High/Medium/Low filter feature allows Disdikbud operators to focus on specific at-risk student groups.

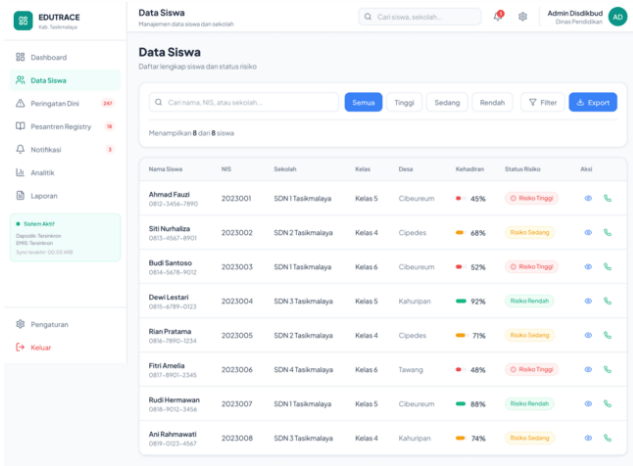


Figure 4. Disdikbud Student Data Page: list of students with attendance and risk status

Figure 5 shows the Pesantren Registry, a critical EDUTRACE module to address the exclusion gap of non-formal pesantren. This portal allows salafiyah pesantren to independently register their students, eliminating the misclassification of active students as ATS [11], [23].

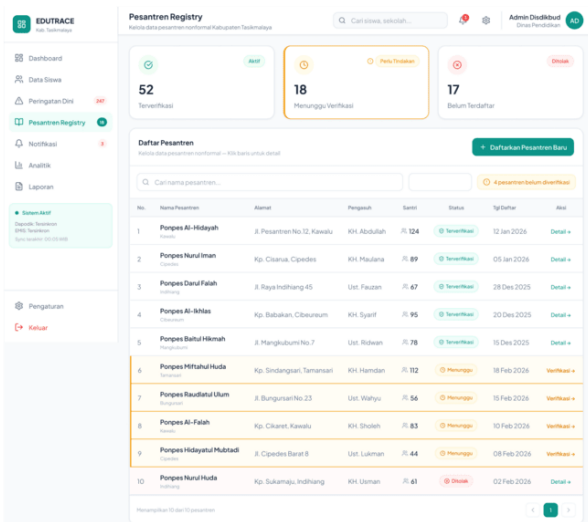


Figure 5. Modul Pesantren Registry: independent registration of non-formal Islamic boarding schools to eliminate false positive ATS

Figure 6 shows the Disdikbud Notification module, which displays a history of all automated alerts sent via the WhatsApp Business API to class teachers, principals, and village officials [14]. Figure 7 displays the Disdikbud Analytics module with in-depth data visualizations covering risk distribution, attendance trends, dominant risk factors, and sub-district comparisons. Figure 8 shows the Disdikbud Report module for generating periodic ATS reports.

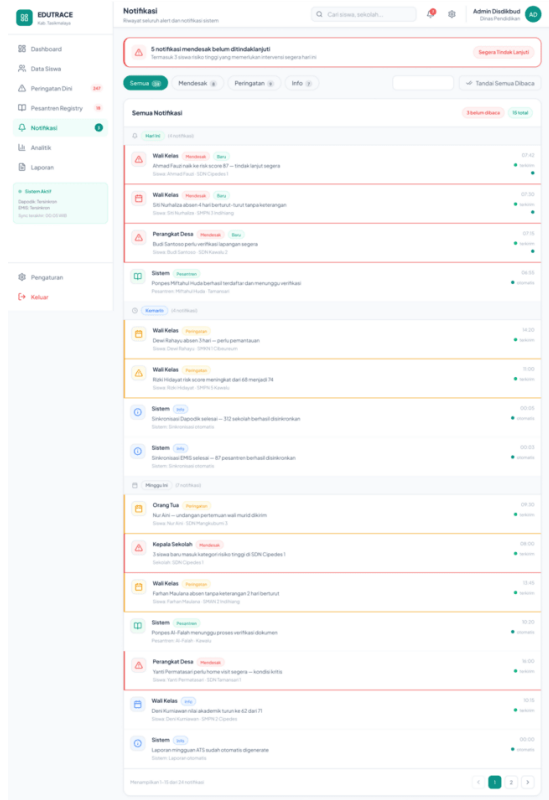


Figure 6. Disdikbud Notification Module: automatic alert history via WhatsApp Business API

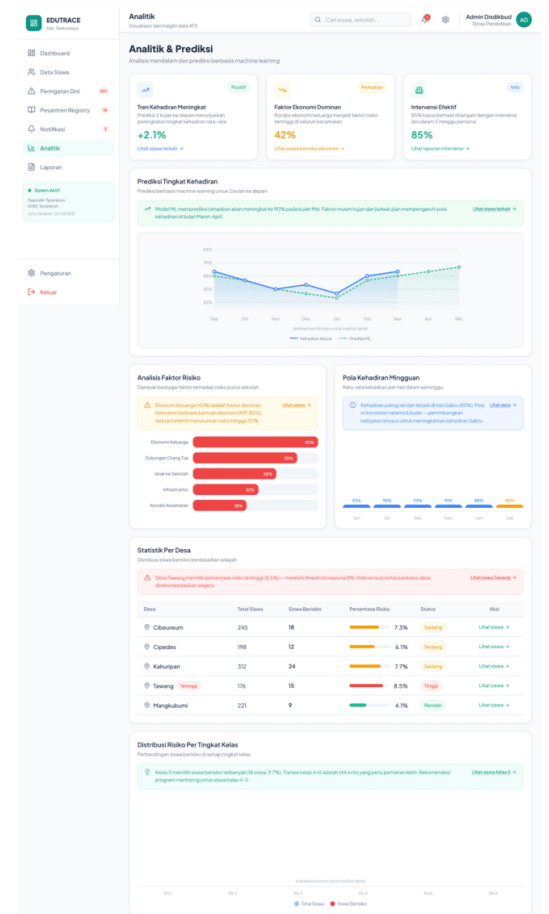


Figure 7. Disdikbud Analytical Module: in-depth visualization of risk distribution and dropout factors

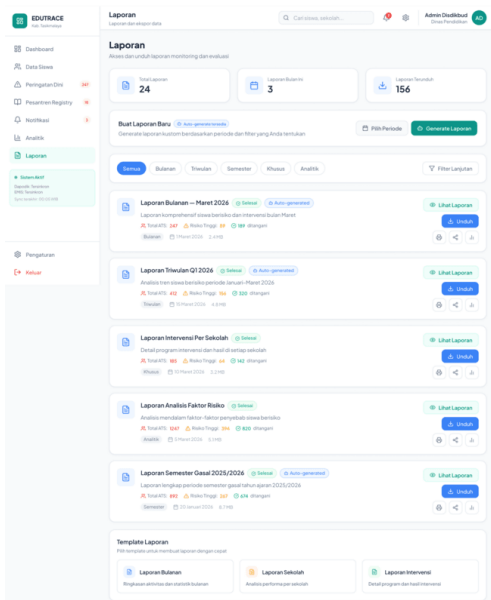


Figure 8. Disdikbud Report Module: generation of periodic ATS reports per sub-district and level

D. Principal Interface

Figure 9 displays the Principal's Dashboard, designed specifically for school-level monitoring. This view focuses data on the specific school, with statistics on at-risk students, attendance trend graphs, and a list of students prioritized for intervention.

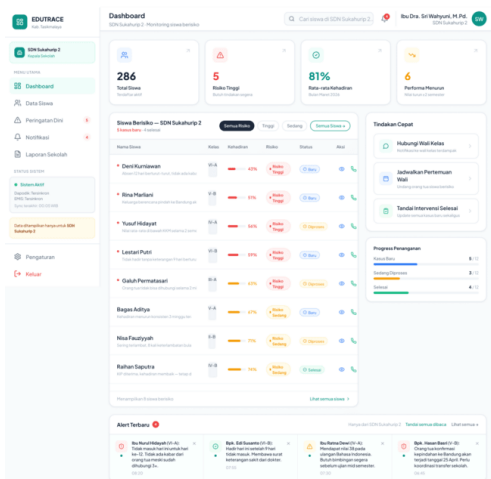


Figure 9. Principal Dashboard: school-level monitoring of at-risk students

Figures 10 and 11 display the Student Data and Principal Early Warning pages. These two modules provide similar functionality to the Disdikbud interface, but with data coverage limited to the school itself, ensuring data privacy between schools.

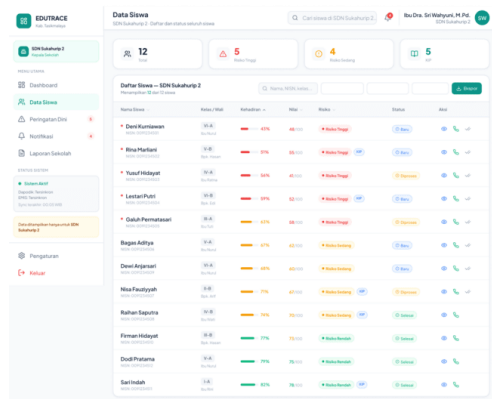


Figure 10. Principal's Student Data Page: coverage is limited to the school itself.

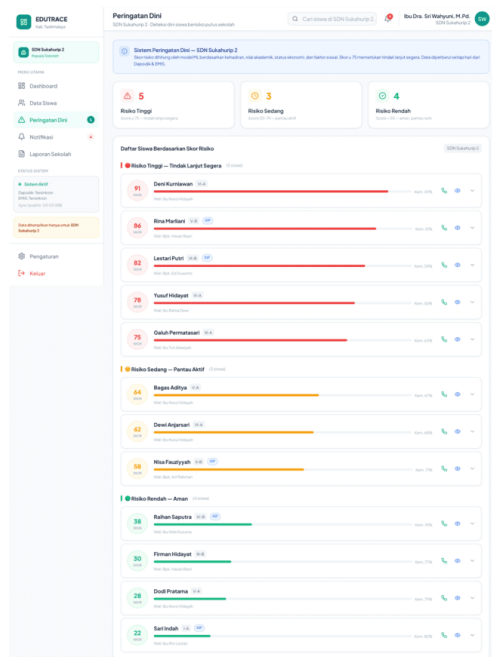


Figure 11. Principal Early Warning Module: identification of at-risk students in the school environment

Figures 12 and 13 display the Principal's Notification and Report modules. The Notification module displays a history of alerts sent and received regarding students at the school, while the Report module allows the principal to generate periodic reports on the ATS status at their school.

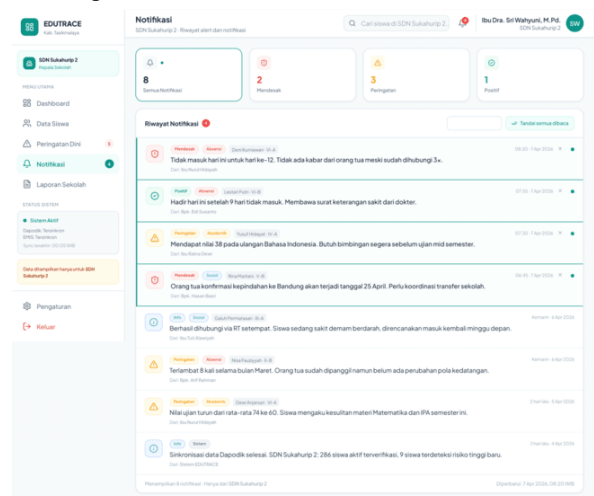


Figure 12. Principal Notification Module: history of at-risk student alerts

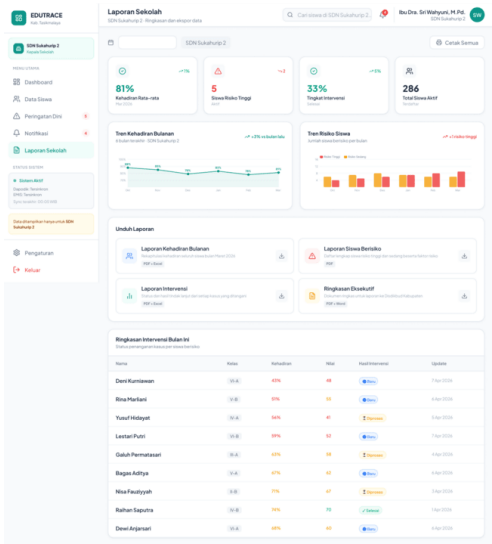


Figure 13. Principal Report Module: periodic report on ATS conditions at school level

E. Village Officials Interface

Figures 14, 15, and 16 display the three Village Apparatus interface modules. The Village Apparatus Dashboard (Figure 14) displays ATS statistics and the status of at-risk students in the relevant village/sub-district. The Student Verification Module (Figure 15) allows village officials to conduct field verification of ATS data to confirm active learning status, family circumstances, or reasons for absence, filling data gaps that cannot be accessed by the formal system. The Notification Module (Figure 16) displays alerts received from the system regarding children in the area who are at risk of dropping out of school.

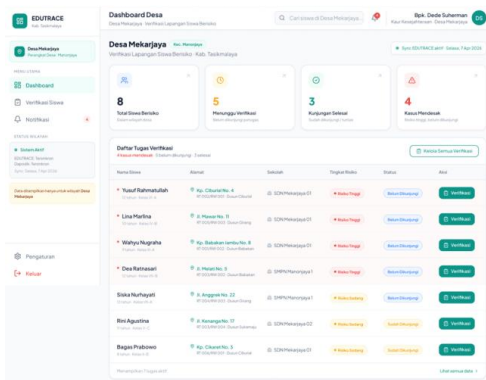


Figure 14. Village Officials Dashboard : ATS statistics and at-risk students at village/sub-district level

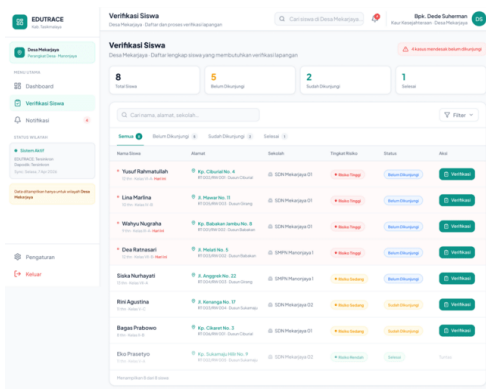


Figure 15. Village Officials Student Verification Module: field confirmation of ATS status in the village area

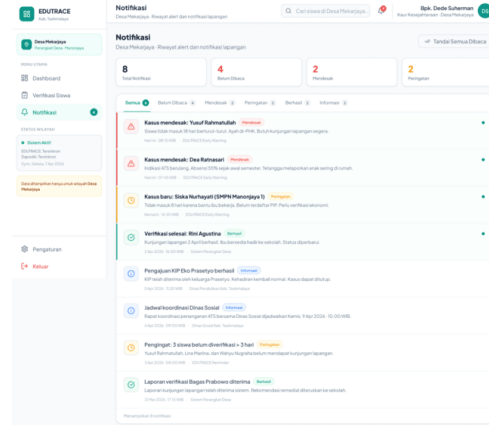


Figure 16. Village Officials Notification Module: receiving warnings of at-risk students in the village area

F. Digital Transformation : Before and After EDUTRACE

TABLE IV

Digital Transformation : Before and After EDUTRACE

Dimension	Before EDUTRACE	After EDUTRACE
Data Resources	Dapodik & EMIS are separate; Islamic boarding schools are not registered	One integrated platform + Islamic Boarding School Registry
ATS Detection	Reactive: after the child has dropped out of school	Preventive : weekly risk score per student (ML)
Notification	None; relies on informal information	Automatic via WhatsApp to three levels of users
Visualization	Static spreadsheet report	Real-time GIS dashboard per village/sub-district
Response Time	Weekly to monthly	1–7 days from risk indicator detection
KIP Targeting	Distributions are not always accurate	Precision targeting based on verified risk profiles
Role of Village Officials	No formal system access	Integrated field verification portal

G. Feasibility Analysis

EDUTRACE's feasibility was assessed across three dimensions. Technically, the system leverages existing government APIs (Dapodik provides authorized third-party access), open-source machine learning libraries (Python, scikit-learn), and open-source GIS tools (Leaflet.js). Institutionally, the system is supported by a robust regulatory framework, including Law No. 20/2003 [1], UU No. 3/2024 about Village [24], Perpres No. 95/2018 about SPBE [25], dan KMA No. 83/2022 regarding the EMIS data integration mandate [23]. Financially, a phased implementation model is proposed: a pilot phase in 2 sub-districts with an estimated cost of Rp 150–250 million (can be funded through the Education DAK), followed by full implementation across all districts at Rp 400–600 million.

H. Alignment with SDGs

EDUTRACE directly supports four SDGs. Under SDG 4 (Quality Education), the system contributes to Targets 4.1,

4.5, and 4.6: ensuring children complete primary education, eliminating educational disparities for vulnerable groups, and providing access to education for Islamic boarding school students [4]. In SDG 10 (Reduced Inequalities), precise targeting of aid ensures that KIP reaches the most vulnerable children [10]. In SDG 16 (Strong Institutions), GIS dashboards strengthen evidence-based decision-making capacity [21].

In SDG 17 (Partnership), the cross-ministerial architecture connects the Ministry of Education and Culture, the Ministry of Religious Affairs, the Ministry of Home Affairs, and village governments in a concrete multi-sector model [24], [25].

IV. CONCLUSION

This paper presents the design and prototype of EDUTRACE, a web-based early warning system for managing out-of-school children in Tasikmalaya Regency. First, the ATS problem in Tasikmalaya and West Java is verified, data-supported, and structurally persistent. The 29,949 ATS cases in Tasikmalaya Regency reflect not only actual absence but also significant data quality failures, particularly the systemic misclassification of active Islamic boarding school students as dropouts [11], [22].

Second, the three most critical systemic gaps—the fragmentation of Dapodik–EMIS, the lack of an early warning mechanism, and the exclusion of non-formal Islamic boarding schools—can be specifically addressed through targeted IT interventions. EDUTRACE offers a realistic, modular, and scalable solution that does not require replacing existing government information systems. By serving as an integration and analytics layer on top of Dapodik, EMIS, and Dukcapil, the system minimizes institutional disruption while providing significantly improved ATS detection, prevention, and inter-agency coordination capabilities.

Third, the prototype proves that all the necessary technical components for API integration, Random Forest-based risk assessment [13], GIS visualization [15], WhatsApp notification [14], and the Village Officials' field verification portal is available as an open-source or low-cost tool. A three-user role architecture (Disdikbud, Principal, Village Official) with appropriate access restrictions ensures data accuracy and accountability at all levels.

The main limitation of this study is the lack of formal usability testing or empirical validation of the prediction model in the Tasikmalaya context. Future research should conduct usability studies with end-users, validate the risk assessment algorithm against actual Dapodik data, and pilot the Pesantren Registry module with a sample of non-formal pesantren in the district.

[CONTENTS: Thanks to the supervising lecturer, the Tasikmalaya Regency Education and Culture Office, or other parties who assisted with this research.]

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