JAISEN: Journal of Advanced Information Systems and Engineering
Vol. 1, 2 (February, 2026), pp 79-86
ISSN: - EISSN: - , DOI: -

Intelligent Chatbot-Based Enterprise Information System for Digital Communication Transformation in Educational Institutions

Solihin Solihin[1], Eddisyah Putra Pane[2], Nurliana Nasution[3]

[1] Master of Computer Science, Lancang Kuning University; stersol09@gmail.com
[2] Master of Computer Science, Lancang Kuning University; pane@unilak.ac.id
[3] Master of Computer Science, Lancang Kuning University; nurliananst@unilak.ac.id

ARTICLE INFO

Keywords:

Enterprise Information System;
Intelligent Chatbot;
Natural Language Processing;
Google Apps Script.

Article history:

Received 2026-01-24
Revised 2026-02-15
Accepted 2026-02-25

ABSTRACT

Effective communication between schools and parents is crucial for achieving educational success. However, SMK Kasih Maitreya Selatpanjang faces challenges due to the use of manual and semi-digital methods, such as WhatsApp, which often cause information delays and administrative inefficiencies. This study aims to analyze communication efficiency improvements and design an enterprise system using an intelligent Telegram chatbot integrated with QR codes for attendance and Google Sheets as a database. Using a qualitative case study approach, data were collected from eight key informants (principals, teachers, staff, students, and parents) through semi-structured interviews, observations, and document analysis. Data were analyzed through transcription, thematic coding and triangulation. The system was successfully implemented with two main features: (1) an automated QR Code-based attendance system that improved time efficiency by 95-97% (averaging 1,490 ms per student), and (2) an intelligent chatbot utilizing DeepSeek NLP, capable of understanding natural conversations with an average response time of 20,420 ms and detecting conversational tone. The results show that conventional systems are highly inefficient, whereas users need real-time notifications for attendance, assignments, and financial information, among others. The implemented Telegram chatbot with NLP, QR Code integration, and Google Sheets synchronization improved administrative efficiency, enhanced information transparency, and increased parental participation.

Corresponding Author:
Solihin Solihin
Master of Computer Science, Lancang Kuning University; stersol09@gmail.com

1. INTRODUCTION

Advances in information technology over the past two decades have driven digital transformation across various sectors, including education. The application of digital technology not only

impacts the learning process, but also significantly affects management information systems, particularly in communication between schools and students' parents. In today's fast-paced digital era, the need for responsive, real-time information systems has become increasingly urgent to ensure active parental involvement in monitoring children's academic progress and discipline in the school environment.

Despite the adoption of various digital communication platforms by many educational institutions, implementation still faces numerous challenges. Most communication processes between schools and parents remain manual or semi-digital, such as WhatsApp groups or electronic circulars. However, these communication models do not fully address the need for adaptive, interactive, and automated services. Consequently, information delays, recording errors, and low parental participation in the educational process occur frequently.

To address these challenges, AI-powered chatbot technology presents a promising and innovative solution. (Lubis et al., 2024) affirm that improving service quality requires transformational breakthroughs, including chatbot integration in instant messaging platforms like WhatsApp or Telegram. Chatbots enable automated two-way interactions, allowing important information such as student attendance, schedules, and discipline notifications to be delivered quickly and accurately.

Furthermore, (Ridha & Haura Maharani, 2022) explain that implementing chatbots in customer service not only handles repetitive queries, but also accelerates response times and enhances user satisfaction. In authentication and verification contexts, Quick Response (QR) code-scanning technology integrated with smartphone cameras has proven effective in simplifying manual data input processes (Imanullah & Reswan, 2022). Using Google Sheets as an online data storage platform enables real-time collaboration and integration with low-code application development platforms, such as AppSheet, which is considered efficient and easily implementable by non-technical users (Yoganata, Irawan, & Yuliana, 2023).

This study focuses on SMK Kasih Maitreya Selatpanjang, a vocational school facing challenges, including high student tardiness rates, delayed task completion, and outstanding educational development contribution payments (SPP) not promptly detected by parents. The main problem is the absence of a systematic, fast, and documented communication system between the schools and parents. The process of conveying information regarding attendance, delays, and SPP arrears remains manual, resulting in time inefficiency, recording error risks, and wasting operational resources.

Based on this background, the research questions were as follows: (1) How can a Telegram-based chatbot system integrated with artificial intelligence improve the efficiency and quality of communication between the school and students' parents/guardians? (2) How can the chatbot system be designed and implemented using the Telegram Bot platform, Google Sheets, and Natural Language Processing (NLP) models to handle main functions such as attendance reporting, payment notifications, and academic consultation?

This research aims to analyze the improvement in communication efficiency and quality and to design and implement a functional chatbot system. The research scope is limited to main school communication functions, using Telegram and Google Sheets platforms and involving key stakeholders at SMK Kasih Maitreya Selatpanjang.

Although previous studies, such as Hartati and Manullang (2024) implemented a Telegram chatbot and Patresia (2022) developed a QR Code-based attendance system, no research has integrated all three components (NLP chatbot, QR Code, Google Sheets) into a single unified ecosystem for school-parent communication.

2. METHODS

This study employs a qualitative research approach with a case study design, focusing on the implementation of a Telegram-based Artificial Intelligence (AI) chatbot system at SMK Kasih Maitreya Selatpanjang. A qualitative approach was chosen to gain an in-depth understanding of the social phenomena and complexities of technology implementation in a real-world context (Purwanza, Wardhana, & Mufidah, 2022). A case study allows for holistic investigation of an event or program within its specific contextual boundaries.

The study population included teachers and educational staff (25 people), students (276 people), and parents/guardians (270 people), totaling to 500 individuals. A purposive sampling technique was used, involving eight key informants: the principal, teachers, homeroom teachers, finance officers, picket teachers, administrative staff, parents, and students. This sample selection was based on consideration of informational depth and strategic roles in the school's communication and administrative processes. The data collection was conducted as follows.

a. Document Study : Analysis of manual attendance records, school committee Fee) recapitulations, and school-parent communication archives.
b. Semi-structured interviews : This study explored informants' perceptions, challenges, and expectations regarding the existing communication system and the proposed chatbot system.
c. Field Observation : Observing the manual attendance process and communication flow within the school environment.

The collected data were analyzed qualitatively through a systematic process comprising the following steps :

a. Data Transcription and Organization : Interview recordings were transcribed and grouped according to informant roles and topics.
b. Thematic Coding : Significant quotes from transcripts were identified, and thematic codes were assigned to capture meanings and patterns.
c. Theme Identification : The codes were grouped into the main themes representing the study's core findings.
d. Data Triangulation : Conducted by comparing the results from interviews, observations, and document studies to ensure data validity and reliability.
e. Interpretation and Conclusion : Findings were analyzed and interpreted to answer the research questions and draw conclusions.

3. FINDINGS AND DISCUSSION

3.1 Analysis of the Existing Communication System Condition

Based on the interview results and document studies, the current communication system at SMK Kasih Maitreya Selatpanjang still relies primarily on WhatsApp Groups (WAG) as the main channel. The Principal stated, "Communication through WAG is quite effective for general announcements, but less suitable for private matters." Sensitive information such as absences, academic progress, and School Committee Fee (SPP) arrears are still conveyed manually through phone calls or personal chats, which is time-consuming and causes miscommunication.

Administrative processes, including attendance recording and SPP arrear recapitulation, are still performed manually using physical books and Excel spreadsheets. The Picket Teacher revealed a constraint, "Attendance recording is still manual and often unsynchronized between the picket teacher and the homeroom teacher." This results in time inefficiency and high potential for human error. Administrative Staff also confirmed that the data recapitulation process was time-consuming and not yet integrated.

3.2 Needs and Expectations for the Chatbot System

All participants responded positively to the plan to implement the chatbot system. The Principal expressed hope that this system would "improve work efficiency and information transparency." Teachers and staff expect automated notifications for attendance, assignments, and SPP (School Development Contribution) bills. One teacher stated, "If there's an automated notification system, it would be very helpful for both teachers' and parents' work."

Parents also expressed a need for faster and easier access to information. One parent mentioned, "It's good because now is the digital era... perhaps matters related to attendance and

assignments can be communicated there." However, there are concerns regarding data privacy and security, as well as the need for socialization, because some parents are not yet familiar with the Telegram platform.

3.3 System Development Design

The development of this intelligent chatbot-based enterprise information system adopted the Agile Development approach with the Scrum model, which was chosen for its flexibility in responding to changing user needs throughout the development cycle. The Scrum model enables iterative development through two-week sprints, involving the product owner (principal and teacher representatives) in each sprint review to ensure that the system aligns with real-world requirements. This approach aligns with the recommendation of Aqil Farras et al. (2025), who demonstrated the effectiveness of the agile method in developing low-code platform applications within organizations with limited resources. The system was designed with a three-tier architecture that clearly separates the user interface, processing logic, and data management. This architecture was chosen to ensure modularity, scalability, and ease of maintenance.

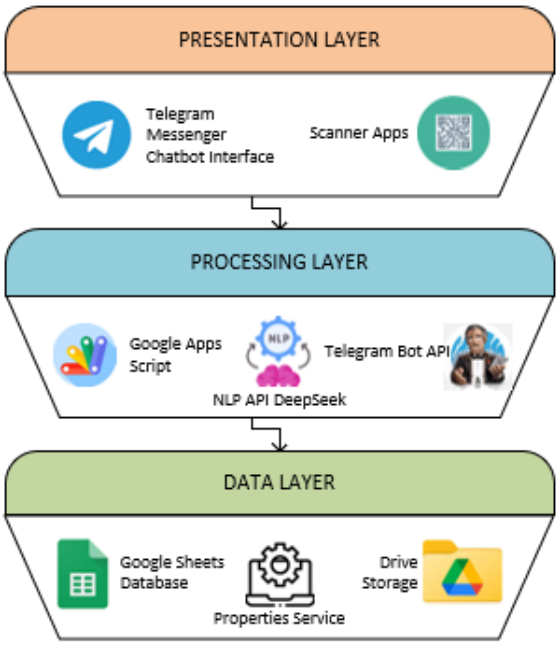

Figure 1. Integrated System Architecture

Presentation Layer functions as the interface that interacts directly with users. This layer consists of two main components: (1) Telegram Messenger, which serves as the primary chatbot platform, chosen for its comprehensive Bot API support, multi-platform capabilities, and widespread penetration among smartphone users in Indonesia (Thomas and Bhat, 2022). (2) A scanner application was developed using React Native, a cross-platform application development framework that enables the application to run optimally on both Android and iOS operating systems. This application is specifically designed to scan static QR Codes on student ID cards using the react-native-vision-camera library.

The Processing Layer is the core of the system, built entirely using Google Apps Script, a serverless development platform within the Google Workspace ecosystem. This layer integrates three critical components: (1) Processing endpoints written in Google Apps Script to handle core functions, such as student data validation, attendance recording, and notification management. (2) The DeepSeek Natural Language Processing (NLP) API, which plays a role in natural language understanding. The DeepSeek model was chosen for its ability to understand conversational context in Indonesian with high accuracy and its support for fine-tuning for specific educational domains (DeepSeek AI, 2024). (3)

The Telegram Bot API manages two-way communication between the system and users through a webhook mechanism, ensuring that every message from users can be processed and responded to in real time.

Data Layer is responsible for system data storage and management. This layer utilizes the Google Workspace ecosystem through three components: (1) Google Sheets as a structured real-time database that stores master's student data, attendance records, tuition payment data, and chatbot conversation logs. The choice of Google Sheets was based on its ease of integration, real-time collaboration capabilities, and free availability and accessibility (Yoganata et al., 2023). (2) Properties Service from Google Apps Script, which is used to store system configurations, manage user sessions, and store temporary caches for performance optimization. (3) Google Drive as a repository for supporting documents, such as report templates, notification archives, and periodic data backups.

3.4 Discussion: Implementation of an Integrated Intelligent Chatbot System

An intelligent chatbot-based enterprise information system was successfully implemented using a three-layer architecture integrating Telegram Messenger, Google Apps Script, and DeepSeek Natural Language Processing (NLP). This architecture was designed using a serverless approach to minimize infrastructure costs and maintenance complexity while ensuring system scalability in serving 276 students and 270 parents at SMK Kasih Maitreya Selatpanjang.

The Presentation Layer consists of two main components: (1) a Telegram Bot functioning as a conversational interface for information services and academic consultations and (2) a React Native-based scanner application used by duty officers to scan static QR Codes on student ID cards. Telegram was selected as the chatbot platform based on its comprehensive Bot API support, multi-device capabilities, and widespread penetration among Indonesian smartphone users (Thomas & Bhat, 2022).

The Processing Layer is built entirely using Google Apps Script running on Google's cloud infrastructure. This layer integrates three critical components: (1) processing endpoints for data validation and business logic, (2) DeepSeek NLP API for intent classification and contextual response generation, and (3) Telegram Bot API for two-way communication with users via a webhook mechanism.

The Data Layer utilizes the Google Workspace ecosystem, with Google Sheets serving as a structured real-time database, Properties Service for configuration and session management, and Google Drive as a repository for the supporting documents. Google Sheets was chosen as a database for its real-time collaboration capabilities, ease of integration via API, and availability at no additional cost (Yoganata et al., 2023).

A static QR Code-based attendance system was designed to replace manual recording, which previously took 30-60 seconds per student and was prone to administrative errors. Each student has an ID card with a QR Code containing their National Student Identification Number (NISN) in an encrypted format. Duty officers use the React Native scanner application to scan the QR code as students enter the school gate. The scanning process triggers a series of automated operations: (1) the scanner application sends the NISN data to the Google Apps Script endpoint via an HTTPS POST request, (2) the system validates student data by matching the NISN against the database in Google Sheets, (3) an algorithm determines attendance status based on the 7:00 AM threshold, (4) the system records attendance with 11 data fields (NISN, name, time, status, class, etc.), and (5) automatic notifications are sent to parents' chat IDs via the Telegram Bot.

Based on the testing of 35 operational samples with controlled duplication scenarios, the system recorded an average response time of 1,490 ms with a standard deviation of ±433 ms. This time encompasses the entire end-to-end process from QR Code scanning, data validation, writing to the cloud database, and sending notifications to parents. Compared to the manual system requiring 30-60 seconds per student, this system provides a 95-97% efficiency improvement in terms of throughput processing time. The relatively tight response time distribution (coefficient of variation 29%) indicates consistent system stability, even under repeated load conditions, with scanning frequencies reaching 0.37 operations per second. This finding aligns with the research (Putri Patresia, 2022) that developed

a QR Code-based attendance system with AppSheet; however, that study did not integrate real-time notifications to parents. The system developed in this study goes further by combining QR Codes, Google Sheets, and the Telegram Bot API into a single integrated architecture, thereby not only recording attendance but also automatically sending notifications to parents.

The intelligent chatbot module was developed by integrating the DeepSeek NLP API to handle natural conversations between parents and the system. The conversation processing flow consists of four data transformation stages: (1) natural language input from the user, (2) intent classification and context understanding by DeepSeek NLP, (3) data retrieval from Google Sheets based on the conversation context, and (4) response generation sent back to the user via the Telegram Bot. The system successfully identified three main intent types in user interactions: general greetings, attendance inquiries, and specific queries regarding a particular child. Test data showed that 42% of interactions were dominated by questions related to student attendance, confirming that parents' primary need is to monitor their children's attendance in real time. Based on the analysis of 12 conversation samples, the system recorded an average processing time of 20,420 ms with a range of 8,700-37,400 milliseconds. There was a positive correlation between response length and processing time, demonstrating the linear scalability of the AI system; output complexity was directly proportional to the required computation time. More significantly, the system demonstrated good tone detection capabilities, including the successful detection of a negative tone in one interaction. This reflects the system's sensitivity to emotional aspects of educational communication, a crucial factor in building empathetic interactions between schools and parents. The system was also designed with the principle of hallucination prevention, where the AI was restricted to using only the existing dataset in Google Sheets and was not authorized to generate its own data. When data are unavailable (e.g., daily attendance details), the AI transparently acknowledges the limitation and suggests alternative sources, such as homeroom teachers or the administrative office. Conversation patterns show natural progressive inquiry—starting from general greetings, specific questions, follow-ups, to closings—reflecting a natural conversation flow similar to that of human interaction.

The system implementation had a significant positive impact on administrative practices and communication within the SMK Kasih Maitreya Selatpanjang. In terms of administrative efficiency, the system successfully automated three main processes that were previously done manually: (1) student attendance recording, which took 30-60 seconds per student, now takes 1.5 seconds per student; (2) monthly attendance recapitulation, which previously required 2-3 working days, is now available in real-time on Google Sheets; and (3) sending tuition fee information, which previously went through a long communication chain (finance department → principal → homeroom teacher → parents), can now be sent directly via chatbot notifications. These findings align with research (Hartati & Manullang, 2024) demonstrating the effectiveness of Telegram chatbots with NLP in educational contexts, as well as research (Lubis et al., 2024) proving that AI chatbots can reduce service time and improve the user experience. However, this study goes further by integrating three key components—NLP chatbots, QR Code attendance, and real-time cloud databases —into a single unified ecosystem specifically designed to address the communication challenges of vocational high schools.

Although the system showed encouraging results, several challenges were identified during its implementation. First, the system is highly dependent on a stable Internet connection. Network disruptions can hinder the QR Code scanning process and notification delivery, consistent with the findings of Irwan et al. (2023) on the importance of network service quality for real-time applications. Second, parents' adoption of the system was constrained by their familiarity with the Telegram platform. Most parents are accustomed to using WhatsApp, thus requiring socialization and assistance during the initial use. Third, the scalability of Google Sheets as a database needs further evaluation for schools with over 500 students, considering the potential bottlenecks in simultaneous read-write operations (Yoganata et al., 2023). Fourth, data security aspects, although relying on the Google Workspace ecosystem, still require additional consideration, especially regarding the storage of sensitive student and parent information.

4. CONCLUSION

Based on the analysis conducted, it can be concluded that the conventional communication system at SMK Kasih Maitreya Selatpanjang is highly inefficient and fails to meet the real-time information needs of parents. The design of an enterprise system based on an intelligent chatbot using the Telegram platform, integrated with QR codes for attendance and Google Sheets as a database, is identified as an innovative and applicable solution.

This system is expected to (1) improve the administrative efficiency of teachers and school staff by automating recording, recapitulation, and information distribution processes; (2) strengthen information transparency by providing real-time access to parents regarding student attendance, assignments, and finances; and (3) increase parental participation and involvement in monitoring children's academic progress and discipline.

For future research, it is recommended to conduct real implementation and testing of the system and evaluate its impact quantitatively (for example, measuring process time before and after implementation and user satisfaction surveys). Further development could include integration with existing school information systems and the addition of more complex features.

Acknowledgments : The authors express gratitude to all informants and the management of SMK Kasih Maitreya Selatpanjang for their participation in this research.

Conflicts of Interest : The authors declare no conflicts of interest in this research.

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