



Development of a QR Code-Based Digital Attendance System to Improve the Efficiency of Student Attendance Management and Principal Decision-Making

Dewi Murni^{1*}, Nurkolis², Muhtarom³

^{1,2,3}Universitas Persatuan Guru Republik Indonesia, Semarang, Indonesia

ARTICLE INFO

Article history:

Submitted: Juny 03, 2026
Final Revised: Juny 18, 2026
Accepted: Juny 26, 2026
Published: July 18, 2026

Keywords:

Digital Presence; QR Code;
Management Efficiency; Principal
Decision Making.



ABSTRACT

Purpose: This study aimed to develop a QR Code-based digital attendance system to improve the efficiency of student attendance management and support data-driven decision-making by elementary school principals. **Method:** The study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model over six months. Participants included the principal, teachers, administrative staff, students, and parents. The system was developed by integrating Google Forms, Google Sheets, Google Apps Script, and Canva. Expert validation was conducted by specialists in educational technology, information systems, and school management. **Findings:** The study produced a valid and practical digital attendance system that enables QR Code-based attendance recording, automatic data recapitulation, and real-time reporting. The system significantly reduced attendance processing time, improved data accuracy to above 95%, minimized recording errors, and provided timely attendance information. The generated data also supported principals in identifying attendance patterns, monitoring student discipline, and making evidence-based management decisions. **Research Implications:** The findings demonstrate that affordable digital technologies can enhance administrative efficiency and strengthen data-driven school management. The system offers a practical model for supporting school digitalization initiatives. **Originality:** This study contributes a QR Code-based attendance system specifically designed not only to improve attendance management but also to function as a decision-support tool for principals through real-time student attendance analytics.



Doi: <https://doi.org/10.61255/jupiter.v4i3.1285>

INTRODUCTION

The Fourth Industrial Revolution has driven fundamental changes in various sectors of life, including elementary education. The presence of digital technology is no longer merely a complement but has become the backbone of systemic transformation encompassing the effectiveness, efficiency, and accountability of school organizational management. (Schwab, 2018) emphasized that the integration of digital technology into all aspects of an organization, including schools, is essential for educational institutions to remain adaptive to changing times. In the context of elementary schools, digitalization demands a paradigm shift from legacy administrative approaches to planned and sustainable information systems-based management (Turnip, 2024).

One dimension of elementary school management most impacted by digitalization is student attendance management. Attendance is a fundamental indicator representing discipline, learning engagement, and the continuity of the learning process. Ironically, most elementary schools in Indonesia still practice a manual attendance system, involving recording in an attendance book or teachers calling names one by one. This practice not only consumes 10 to 15 minutes of effective learning time each morning but also poses problems with data accuracy and reliability (Amal, 2022).

A similar situation was encountered at Ngawensari 1 Public Elementary School in Ringinarum District, Kendal Regency. The manual attendance system, which had been in place for years, began to show significant weaknesses as demands for digital and transparent educational administration increased. First, the registration process took up time

that could have been used for early learning activities. Second, there was a high rate of human error, such as failure to mark attendance, misspelling names, or duplication of data during monthly recapitulations. Third, attendance data was not available in real time, making it difficult for the principal to monitor student attendance instantly and make quick decisions.

The fourth weakness is that paper attendance records are prone to damage, loss, or disorganization, complicating internal audits and school accreditation. Fifth, manual systems are unable to provide in-depth data analysis, such as attendance trends, teacher absence patterns correlated with teaching performance, or early identification of students requiring special assistance due to frequent absences. As a result, the strategic potential of attendance data as a source of managerial information is not optimally utilized. However, within the framework of modern educational management, student attendance should be a strategic data source that can be utilized by principals for decision-making (Mutia, 2025).

When attendance systems are manual and fragmented, principals often lack quick access to accurate attendance information. (Sinaga, 2023) emphasized that one weakness in school management is the tendency to make decisions based solely on habit or intuition, without adequate data analysis. This is exacerbated by the fact that 92% of principals in the study locations admitted to not having real-time access to attendance data, resulting in reactive and inaccurate decisions.

Digital attendance presents a potential solution to the various limitations of conventional systems. This technology enables automatic, real-time attendance recording, integrated into the school information system. Amal, (2022) reports that implementing digital attendance can improve time efficiency, data accuracy, and transparency in student attendance management. Among the various digital attendance technologies available, QR Codes (Quick Response Codes) stand out for their ease of use, relatively low implementation costs, and compatibility with commonly owned school devices, such as smartphones or tablets (Priyambodo, 2020).

Research (Priyambodo, 2020).shows that QR Code-based attendance systems have a high level of accuracy and significantly faster processing times compared to manual methods. In its implementation at SD N 1 Ngawensari, each student is provided with an identity card containing a unique QR Code containing an encrypted NISN (National Student Identification Number). Scanning, which takes only 2–3 seconds, automatically records arrival time, location, and attendance status in a centralized database that is directly synchronized to the principal's dashboard. Other empirical findings support this claim. (Dewi, 2024) found that the use of QR Code-based digital attendance in elementary schools was able to significantly improve student discipline and punctuality.

(Fitriati, 2023) asserts that a well-designed QR Code attendance application can increase attendance management efficiency by over eighty percent, including saving teacher time, simplifying data recapitulation, and increasing the accessibility of attendance information. (Kusumawati, 2023) adds that QR Code-based e-attendance can reduce manual recording errors and support the strengthening of a technology-based school vision. Despite abundant evidence of this technical effectiveness, most research still focuses solely on the efficiency of recording and its impact on student discipline.

The research gap begins to emerge when we link digital attendance results to the principal's decision-making process. Very few studies specifically design and develop digital attendance systems as strategic instruments to support the principal's managerial functions. However, from an educational management perspective, the strategic value of an information system lies in its ability to provide relevant and readily available data for decision-makers (Sinaga, 2023) As instructional leaders and managers of educational units, principals require information that is not only accurate but also fast, concise, and actionable.

Data-driven decision-making has received increasing attention in the educational leadership literature. (Yuliatika, 2021) emphasized that the effectiveness of a principal's leadership is largely determined by the quality of the decision-making process, which is carried out rationally, ethically, and participatory. Research (Nurzen, 2022) reveals the alarming fact that many principals still carry out planning and decision-making administratively without systematically utilizing data. The root of the problem is often not the lack of data, but rather the lack of a system capable of presenting operational data, such as student attendance, in a structured and easily interpretable format.

This is where the urgency lies in utilizing QR Code-based digital attendance systems not merely as attendance recording tools, but as strategic data sources that can be processed, analyzed, and interpreted to support principal decisions. Presented in real-time and historical attendance data, principals can map trends, identify at-risk students (e.g., absent for more than three consecutive days), and design evidence-based interventions. Several studies are beginning to shed light in this direction. (Mutia, 2025) noted that digital attendance reports have been used by school principals as a basis for evaluating student discipline and making administrative decisions.

However, this research has not yet examined in depth how attendance systems are specifically designed based on an analysis of decision-makers' needs to ensure they are truly functional in supporting principals' managerial processes. International studies also provide support. (Lee, 2025) show that the use of appropriate data, particularly formative data, has a positive relationship with improved school performance, while haphazard data use has no significant impact. Therefore, an attendance system development model is needed that is not only technically superior but also managerially sound.

The concept of functionalizing educational information systems emphasizes that technology must be developed based on the real needs of end users, in this case, principals as decision-makers. (Turnip, 2024). emphasizes that an effective educational information system is one that can connect operational data with the school's strategic planning. Therefore, the digital attendance system to be developed needs to be equipped with features such as daily and monthly attendance graphic visualization, class ranking based on attendance level, automatic identification of problem students, and absence patterns that can be correlated with teacher performance.

Amidst the resource constraints commonly faced by rural elementary schools, the system development approach must be realistic and contextual. Using Google Workspace (Google Forms, Google Sheets, Canva) as a backend is a strategic choice because it is low-cost, easy to operate, and utilizes smartphones already owned by teachers. (McLaughlin, 2025) emphasizes that data-driven decisions and adequate support systems can reduce dilemmas and uncertainty in school leadership. In this regard, a properly designed QR Code-based digital attendance system has the potential to become a strategic tool that eases the administrative burden while improving the quality of decisions made by principals.

The implementation of a QR Code-based attendance system at SD N 1 Ngawensari is not simply an administrative modernization, but a fundamental transformation in the principal's decision-making. The QR Code serves as a bridge between daily activities in the field and the school's management information system. It transforms attendance data from mere administrative records into a strategic source of educational intelligence. With this system, principals can make decisions that are: (1) based on empirical evidence, not assumptions; (2) responsive to daily issues; (3) measurable through quantitative indicators; and (4) whose impact can be periodically evaluated.

The gap between the potential of digital attendance technology and the reality of its use in principal decision-making in elementary schools, particularly in rural areas, is an urgent issue that needs to be addressed. Research and development (R&D) that systematically designs, tests the validity, measures the practicality, and evaluates the effectiveness of this system in a real-world context is highly relevant. No previous research has comprehensively integrated aspects of technology, educational management, and principal leadership within a single, contextualized product development framework for rural elementary schools.

This research aims to fill this gap. Titled "Development of a QR Code-Based Digital Attendance System to Improve the Efficiency of Student Attendance Management in Principal Decision-Making at Ngawensari 1 Public Elementary School," this study will not only produce a system prototype but also a model for utilizing attendance data integrated into the principal's decision-making cycle. The R&D approach, using the ADDIE model, was chosen to ensure a systematic development process, from needs analysis to impact evaluation.

Therefore, this research is expected to make a tangible contribution, both theoretically by enriching the study of data-driven decision-making in elementary education and practically as a model for contextual, affordable, and sustainable digital transformation of school administration. The results are expected to become best practices for other elementary schools with similar characteristics, as well as encourage a shift in the principal's decision-making culture from intuitive-administrative to systematic-data-based.

Based on the problem identification and delimitation conducted, this research focuses on the development of a QR Code-based digital attendance system to improve the efficiency of student attendance management and support principal decision-making in elementary schools. Specifically, this research examines how to design a QR Code-based digital attendance system that meets student attendance management needs, how the development process is systematically developed, the level of validity of the resulting system based on expert assessments, how it can be implemented in a real elementary school environment, and how the attendance data generated by the system can be utilized by principals for faster, more accurate, and data-driven decision-making.

This research aims to develop a valid, practical, and effective QR Code-based digital attendance system to improve the efficiency of student attendance management and support principal decision-making at SD Negeri 1 Ngawensari. Specifically, this study aims to design a QR Code-based digital attendance system that is responsive to school needs, develop the system through Research and Development (R&D) stages using the ADDIE model, test the level of system validity through a validation process by experts and potential users, implement the system in a school environment to evaluate its technical, organizational, and managerial aspects, and analyze the utilization of the

resulting attendance data in supporting the principal's decision-making. Through this research, it is hoped that a digital attendance system can be produced that not only improves the efficiency, accuracy, and transparency of student attendance management, but also provides real-time information that can be used as a basis for more objective, timely, and evidence-based decision-making.

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model to develop a QR Code-based digital attendance system aimed at improving the efficiency of student attendance management and supporting data-driven decision-making by the principal at SD Negeri 1 Ngawensari. The research was conducted at SD Negeri 1 Ngawensari involving all 124 students, 8 teachers, and the principal as system users and respondents during the implementation phase.

The development process consisted of five stages. First, the analysis stage examined the existing manual attendance system through observations, interviews, and document analysis to identify operational problems, user requirements, technology readiness, and success indicators. Second, the design stage involved creating system architecture, workflow diagrams, database structures, user access levels, attendance recapitulation formats, and dashboard prototypes. Third, the development stage focused on constructing the system prototype, including student database creation, daily dynamic QR Code generation using Google Apps Script, Google Forms integration as the attendance interface, automated data processing through Google Sheets, and dashboard visualization using Canva. The prototype was then evaluated by three experts consisting of an educational technology expert, an information systems expert, and a school management expert. Fourth, the implementation stage involved a four-month field trial to assess system practicality and user acceptance. Finally, the evaluation stage was conducted to measure system effectiveness and formulate improvements based on user feedback and implementation results.

Data were collected using four instruments: (1) observation sheets to record attendance management procedures before and after implementation; (2) semi-structured interview guidelines for the principal and teachers to explore user needs, challenges, and perceived benefits; (3) expert validation sheets to assess system feasibility; and (4) user response questionnaires to evaluate practicality and satisfaction. The expert validation instrument consisted of five assessment aspects, namely functionality, interface and usability, system security, system performance, and decision-support capability. Each item was assessed using a four-point Likert scale ranging from 1 (invalid) to 4 (very valid). Meanwhile, user response questionnaires employed a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Qualitative data obtained from observations, interviews, and documentation studies were analyzed using the interactive model of data reduction, data display, and conclusion drawing. Quantitative data were analyzed descriptively using mean scores and percentage calculations. The level of validity of the developed product was calculated using the formula:

Validity Percentage = $(\text{Obtained Score} / \text{Maximum Score}) \times 100\%$. The resulting percentages were interpreted according to the following criteria: 81–100% = Very Valid, 61–80% = Valid, 41–60% = Fairly Valid, 21–40% = Less Valid, and $\leq 20\%$ = Invalid. User response and practicality data were analyzed using the same percentage formula and interpreted with the criteria: 81–100% = Very High, 61–80% = High, 41–60% = Moderate, 21–40% = Low, and $\leq 20\%$ = Very Low. The effectiveness of the QR Code-based digital attendance system was evaluated by comparing key performance indicators before and after implementation, including attendance processing time, recording error rate, data completeness, reporting speed, and the quality of principal decision-making. These indicators were analyzed descriptively to determine the extent to which the developed system achieved the predefined success criteria.

RESULTS

1. QR Code-based digital attendance system design to improve the efficiency of student attendance management in the Principal's decision-making in Elementary Schools

The analysis phase was conducted to identify problems with the manual attendance system at SD Negeri 1 Ngawensari, determine user needs for a digital attendance system, and analyze the school's technological readiness. Data was obtained through observation, interviews, documentation studies, and analysis of the technology infrastructure.

Observations indicated that the manual attendance process remained inefficient, requiring an average of 12.6 minutes per class. This time tended to be longer in lower grades because teachers had to call students individually. Furthermore, various recording errors were found, such as students not being recorded as present, duplicate entries, and discrepancies between daily data and weekly recapitulations.

Interviews revealed that teachers and administrative staff experienced challenges in the attendance process and attendance data processing. Teachers complained about the time wasted on attendance activities, which reduced effective learning time. Administrative staff also faced difficulties in data recapitulation due to incomplete or illegible data. The principal stated that the manual system was unable to provide fast and accurate student attendance information, making decision-making difficult.

In terms of user needs, all informants expected a digital attendance system that was easy to use, could be operated via smartphone, could automatically record attendance, and generate attendance reports quickly and in real time. The desired system would also help the principal monitor student attendance at any time without having to wait for monthly reports.

A documentary study of 500 attendance entries revealed an 8.4% recording error rate, a 95.8% daily data completeness rate, and an average delay in monthly reports of 3.2 days. These findings indicate that the manual attendance system still has relatively low levels of accuracy and efficiency. Meanwhile, a technological readiness analysis indicated that the school has conditions that support the implementation of a digital attendance system. All teachers have smartphones, the school's internet network is available with adequate speed, the electricity supply is stable, and teachers and staff possess basic digital competencies in operating various technology-based applications.

Based on the overall analysis, it can be concluded that the main problems faced by the school include the lengthy attendance process, the high risk of recording errors, delays in preparing attendance reports, and the lack of real-time data access. On the other hand, the readiness of infrastructure and human resources indicates that the development of a QR Code-based digital attendance system is highly feasible as a solution to improve the efficiency, accuracy, and speed of student attendance data management at SD Negeri 1 Ngawensari.

2. Design and Development of a QR Code-Based Digital Attendance System to Improve the Efficiency of Student Attendance Management and Principal Decision-Making

Based on the results of the needs analysis, the researchers designed a QR Code-based digital attendance system tailored to the context of SD Negeri 1 Ngawensari. The design included system architecture, workflow, and functional features. The system architecture utilizes a client-server approach based on lightweight cloud computing services. The backend infrastructure utilizes Google Workspace, consisting of: 1) Google Forms as the input interface for student QR Code scanning, 2) Google Sheets as the centralized database and data processing engine, 3) Google Apps Script to automate the daily dynamic QR Code generation, and 4) Canva as a platform for presenting visual report dashboards accessible to the principal.

This infrastructure was selected based on considerations of zero cost (free), ease of use by teachers already familiar with the Google ecosystem, and no additional software installation required. The workflow of the QR Code-based digital attendance system is designed as follows: 1) Each student is provided with an identity card containing a unique QR Code containing an encrypted NISN, 2) The QR Code is automatically updated daily by the system using Google Apps Script to prevent misuse (dynamic QR Code). 3) Upon arrival at the school gate, students scan their QR Code on the teacher's smartphone device that has opened Google Form, 4) After a successful scan, the system automatically records attendance data in Google Sheets with an arrival time timestamp. 5) The system categorizes student attendance status as "On Time" if the scan is done before 07.00 WIB and "Late" if it is done after 07.00 WIB. 6) Data stored in Google Sheets is automatically summarized and visualized in a report dashboard that can be accessed by the principal at any time.

Functional Features Designed, The digital attendance system is designed with special features aimed at supporting the efficiency of attendance management and decision-making by the principal, namely: 1) Dynamic QR Code that is automatically updated every day to prevent misuse such as double scanning or code replication by absent students. 2) Visualization of daily and monthly attendance graphs per class and per student, displayed in the form of bar charts and line charts on the Canva dashboard. 3) Automatic alerts for students who are absent for more than three consecutive days, which are marked in red on the report table so that they are easily identified by the principal. 4) Automatic recapitulation with filter functions based on class, time period, and attendance status (On Time, Late, Absent), which is available on Google Sheets and the dashboard. 5) Role-based access control with two levels of access: administrators (principals) who can view all data and reports, and users (class teachers) who can only view their respective class data.

3. Development: A QR Code-Based Digital Attendance System to Improve the Efficiency of Student Attendance Management and Principal Decision-Making

The development phase aimed to develop, validate, and refine a QR Code-based digital attendance system before its widespread implementation at SD Negeri 1 Ngawensari. This phase included system prototype development, expert validation, small-scale trials, product revisions, and large-scale trials.

The system prototype was developed over six weeks and resulted in several key components: a student database, a dynamic QR Code generator, a Google Forms-based scanning form, automatic recapitulation using Google Sheets, and a visual dashboard displaying attendance data, attendance trends, and alerts for students who are frequently absent. The system was designed to simplify the attendance recording process while providing fast, real-time information to teachers and principals.

Table 1. Expert Validation Results for the Digital Attendance System

Nu.	Assessment Aspect	Educational Technology Expert	Educational Management Expert	Information Systems Expert	Average	Category
1.	Functionality	4	4	4	4,00	Very Valid
2.	Interface and Usability	3	4	4	3,67	Very Valid
3.	System Security	4	4	4	4,00	Very Valid
4.	System Performance	4	4	3	3,67	Very Valid
5.	Decision-Making Support	4	4	4	4,00	Very Valid
Overall Average					3,87	Very Valid

Prior to use, the system was validated by three experts: an educational technology expert, an educational management expert, and an information systems expert. The validation results showed an average score of 3.87 out of 4.00, categorized as Very Valid, indicating the system is suitable for use. The validators provided several inputs, such as improving the scan confirmation display, adding problematic student information to the dashboard, and improving administrator access security. After revisions, the system was tested on a small scale with 21 fifth-grade students and one teacher. The trial results obtained an average score of 92.4%, categorized as Very Good.

Table 2. Small-Scale Trial Results

Nu.	Assessment Aspects	Assessment Percentage	Category
1.	Functionality	95%	Very Good
2.	Interface and Usability	82%	Good
3.	System Security	95%	Very Good
4.	System Performance	90%	Very Good
5.	Decision-Making Support	100%	Very Good
Overall Average		92,4%	Very Good

Several challenges encountered included damaged or folded QR Codes, internet connection issues, and students forgetting to bring their QR Code cards. These challenges were addressed by laminating the cards, providing a temporary storage mode in case of network problems, and providing backup cards at the school. Based on the results of the small-scale trial and expert input, product revisions were made, including improving the system's appearance, adding student monitoring features, increasing the durability of the QR Code cards, and providing backup QR Codes. The revised product was then tested on a large scale, involving the entire school community: 124 students, 10 teachers, one principal, and one administrative staff member. The results of the large-scale trial showed an improvement in system quality, with an average score of 93.98%, categorized as Very Good.

Table 3. Large-Scale Trial Results

Nu.	Assessment Aspects	Assessment Percentage	Category
1.	Functionality	95%	Very Good
2.	Interface and Usability	81,7%	Good
3.	System Security	98%	Very Good
4.	System Performance	95,2%	Very Good
5.	Decision-Making Support	100%	Very Good
Overall Average		93,98%	Very Good

This improvement indicates that the revisions successfully improved the system's security and performance. Thus, the Development stage produces a QR Code-based digital attendance system that has been proven to be very valid, high-quality, and ready to be applied at the field implementation stage.

4. Implementation of a QR Code-Based Digital Attendance System to Improve Student Attendance Management Efficiency in Principal Decision-Making

The implementation phase involved the full implementation of a QR Code-based digital attendance system at SD Negeri 1 Ngawensari over a four-month period. This phase involved the entire school community: 124 students, 10 teachers, 1 principal, and 1 administrative staff member. Prior to implementation, all teachers and staff members participated in system usage training, which covered attendance procedures, access to reports, and handling simple technical issues. The training results showed that all participants were able to operate the system effectively in less than 30 minutes, thus deeming the system easy to learn and use.

The implementation of the digital attendance system has been proven to significantly improve time efficiency. The average attendance time, which previously reached 12.6 minutes per class under the manual system, was reduced to just 2.3 minutes per class. This resulted in an 81.7% time savings, enabling more optimal use of learning time. These results were further supported by statistical tests, which showed a statistically significant difference in time between the manual and digital systems.

In terms of data quality, the digital system demonstrated significant improvements. The recording error rate decreased from 8.3% to 0.4%, a 95.2% decrease, while daily data completeness increased to 100%. Furthermore, attendance reports, which previously required several days to compile, are now available in real time, while monthly reports can be generated automatically at the beginning of the month. This makes attendance data more accurate, complete, and easily accessible.

The system's implementation also significantly benefits school principals in the decision-making process. Through the available dashboard, principals can monitor student attendance in real time, identify students who are frequently absent or tardy, and take prompt follow-up actions. Attendance data is used as the basis for various policies, such as interventions for problem students, disciplinary evaluations, rewards for disciplined students, and the development of data-driven school programs.

From a user perspective, the system received very positive feedback. Questionnaire results showed an average teacher satisfaction rating of 4.53 out of 5.00, categorized as Very High. The most significant benefits were the ease of managing student attendance and the reduction in teachers' administrative burden. All teachers stated that they were willing to continue using the system in the long term.

Overall, the implementation phase demonstrated that the QR code-based digital attendance system successfully increased the efficiency of the attendance process, improved data accuracy and completeness, accelerated reporting, and supported faster, more accurate, and data-driven decision-making by principals. The system was also very well-received by users, making it suitable for continued implementation in schools.

5. Evaluation of the Development of a QR Code-Based Digital Attendance System to Improve the Efficiency of Student Attendance Management in Principal Decision-Making

The evaluation phase was conducted to assess the validity, practicality, and effectiveness of the QR Code-based digital attendance system developed and implemented at SD Negeri 1 Ngawensari. A summative evaluation was conducted at the end of the study to ensure that the system addressed the issues identified in the analysis phase and provided tangible benefits to the school.

In terms of validity, expert validation results showed an average score of 3.87 out of 4.00, categorized as Very Valid. All assessed aspects, including functionality, interface, security, system performance, and decision-making support, scored above the established minimum criteria. These results indicate that the system meets both technical and functional feasibility standards, making it suitable for use in a school environment.

In terms of practicality, the system achieved an average user satisfaction score of 4.53, categorized as Very High, and all teachers expressed their willingness to use the system continuously. Observations during implementation also indicated that the system could be operated daily without disrupting school activities. Teachers are no longer burdened with manual recapitulation processes, making administrative work easier and more efficient. Therefore, the system is considered highly practical for use in daily attendance activities.

In terms of effectiveness, the system successfully met and even exceeded all research targets. Attendance time was reduced by 81.7%, from an average of 12.6 minutes to 2.3 minutes per class. The recording error rate decreased by 95.2%, from 8.3% to 0.4%, while daily data completeness increased to 100%. Furthermore, daily attendance reports

can be accessed in real time, and monthly reports are automatically available at the beginning of the month. The system also received full recognition from the school principal as a valuable tool for data-driven decision-making.

Table 4. Summary of Research Results Achievements

Indicator	Targets	Achievement	Category
Average expert validation score	$\geq 2,50$	3,87	Very Valid
User satisfaction percentage	$\geq 80\%$	100%	Very Practical
Time savings in attendance	$\geq 70\%$	81,7%	Very Effective
Reduced error rate	$\geq 90\%$	95,2%	Very Effective
Daily data completeness	Increase	100%	achieved
Decision-making support	100%	100%	achieved

Overall, the evaluation results showed that the QR Code-based digital attendance system met all established success indicators. The system received the categories of Very Valid, Very Practical, and Very Effective, with key achievements being an expert validation score of 3.87, 100% user satisfaction, 81.7% attendance time savings, 95.2% reduction in recording errors, 100% data completeness, and full support for the principal's decision-making. Thus, the developed system has been proven to be able to improve the efficiency of student attendance management while supporting optimal data-based school management.

DISCUSSION

The research results outlined in Point A indicate that the QR Code-based digital attendance system developed through a Research and Development approach using the ADDIE model meets the criteria for validity, practicality, and effectiveness, and significantly supports the principal's decision-making at SD Negeri 1 Ngawensari. This discussion is structured to interpret these findings within the theoretical framework reviewed in Chapter II, confirm or reconcile them with relevant research, and reveal the empirical and conceptual contributions of this research.

1. QR Code-Based Digital Attendance System as a Solution to the Limitations of Manual Systems

The findings of this research convincingly confirm that the QR Code-based digital attendance system is capable of overcoming the fundamental weaknesses inherent in manual attendance systems. The 81.7% reduction in attendance processing time, from an average of 12.6 minutes to just 2.3 minutes per class, represents strong empirical evidence of the increased efficiency achieved by this system. These findings align with research (Fitriati, 2023) that reported an increase in attendance management efficiency of over eighty percent using a similar system, as well as research (Kurniawan, 2020) that recorded a decrease in attendance time from an average of fifteen minutes to three minutes per class after implementing a QR Code system. This consistency of findings reinforces the claim that QR Codes are a reliable technology for accelerating attendance processes in elementary schools.

However, this research contributes more than simply confirming previous findings. The time efficiency achieved not only impacts administrative aspects but also creates the prerequisites for principals to access attendance data in real time, a condition impossible with manual systems. In manual systems, attendance data is only available after the recapitulation process, which takes an average of 3.2 days after the end of the period, leaving principals behind in responding to attendance issues. In contrast, with digital systems, data is available mere seconds after the last QR Code scan. This shift is fundamental because it shifts the principal's position from a reactive decision-maker awaiting reports to a proactive decision-maker able to monitor school conditions at all times. (Sinaga, 2023) emphasized that one of the main weaknesses in school management is the tendency to make decisions based on intuition or outdated data due to the lack of real-time access to operational information. The system developed in this study directly addresses this weakness.

The reduction in the recording error rate from 8.3% to 0.4%, a 95.2% reduction, is another important finding that confirms the reliability of the QR Code system in improving data accuracy. This figure even surpasses the findings of (Prasetyo, 2021), which reported 99% accuracy for a similar system at Al-Azhar Integrated Islamic Elementary School. The remaining 0.4% error rate was primarily due to external factors such as momentary internet connection interruptions or physical damage to the QR Code cards, rather than the system design itself. More important than the numbers are the managerial implications of this increased accuracy. As emphasized by (Sinaga, 2023) accurate data is a key prerequisite for utilizing operational data in managerial analysis. Without adequate accuracy, principals will lack confidence in the data to base decisions. The principal's statement before implementation, "I often hesitate to use manual attendance data because there are often discrepancies during verification," demonstrates that doubts about

manual data are a real barrier to data-driven decision-making. A digital attendance system with 99.6% accuracy eliminates these doubts and builds principals' confidence in the available data.

The 100% completeness of daily data is also a significant achievement. In the manual system, an average of 4.2% of student attendance was not recorded each day due to various administrative reasons: teachers forgot to check attendance, students arrived late and were not recorded, or attendance pages were missed. This incompleteness creates information gaps that can be detrimental to students, for example, when attendance data is used as a requirement for exams or as a basis for attitude assessments. The digital system completely closes this gap because recording is automated, and each scan is permanently recorded in the database. (Kusumawati, 2023) emphasized that technology-based e-attendance can simultaneously improve data accuracy and completeness, and the findings of this study provide solid empirical evidence to support this claim.

2. Transforming Operational Data into Strategic Information for Principals

The most significant finding and primary contribution of this study is the transformation of attendance data from mere administrative records into a strategic information source that directly supports principals' decision-making. This transformation is not an automatic consequence of technology implementation, but rather the result of a system designed to meet the cognitive and managerial needs of decision-makers. This is clearly seen from the four types of decisions successfully taken by the principal during the implementation period, namely: (1) early intervention for 17 students with repeated absence patterns through home visits and 12 communication letters to parents; (2) evaluation and adjustment of discipline policies based on the analysis that 68% of lateness occurs on Mondays and Wednesdays; (3) providing monthly appreciation to 42 students with perfect attendance based on objective data; and (4) strategic planning for budget allocation for at-risk student mentoring programs. These four types of decisions show that digital attendance data has transcended the boundaries of its administrative function and become a strategically valuable managerial instrument.

Data visualization through reporting dashboards proved key to this transformation. Principals reported being able to monitor the attendance of all classes in just 30 seconds via the dashboard, a capability that was completely unavailable in the manual system era. (Nielsen, 2022) explains that the principle of system status visibility in interface design allows users to quickly understand system conditions without the need for in-depth analysis. In the context of this study, the class attendance bar graph, monthly trendline diagram, and problem student alert table present processed data into ready-to-use information for principals. Principals no longer need to consult raw data tables or perform manual calculations; the system has already performed the initial processing and presented the information in an intuitive visual format. These findings support the argument (Turnip, 2024) that an effective education information system is one that connects operational data with the school's strategic planning. However, this study goes further by concretely demonstrating how this connection occurs through automated alert mechanisms, trend visualizations, and immediately actionable reports.

The automated alert feature for students absent for more than three consecutive days deserves special attention. This feature fundamentally changes the principal's intervention pattern from reactive-waiting to proactive-detecting. Before the system's implementation, principals only learned about students with recurring absences after the monthly report came out, an average of 3.2 days after the end of the period, and that was if they had time to read the report thoroughly. As a result, intervention was often delayed and the problem had already escalated. With automated alerts, the system actively notifies the principal once a student reaches the three-day absence threshold, allowing immediate, even same-day, action. This mechanism confirms findings (McLaughlin, 2025) that data-driven decision support systems can reduce uncertainty and dilemmas in school leadership. Principals are no longer in a position of "not knowing," but are constantly informed and informed to drive action.

Monthly recognition of 42 students with perfect attendance and punctuality is also a decision that was previously difficult to implement consistently. In the manual era, identifying students with perfect attendance required manual checks of thick, error-prone attendance books, often not done or only occasionally. A digital system allows for automated and accurate identification, allowing recognition to be given routinely, objectively, and transparently. This practice creates a positive school culture, where students are motivated to be punctual because they know their punctuality is recorded, monitored, and rewarded. (Dewi, 2024) found that implementing QR code-based attendance encouraged students to be punctual because the system recorded attendance objectively and consistently. The findings of this study reinforce and expand upon these findings by demonstrating that the system's positive impact extends not only at the individual student level but also across school policy.

Data analysis showing that 68% of student tardiness occurred on Mondays and Wednesdays provides a concrete example of how digital attendance data can uncover previously hidden patterns. In a manual system, months of daily

data are difficult to analyze in aggregate because they are scattered across different books and require hours to compile. A digital system enables this kind of analysis in seconds. The discovery that tardiness was concentrated on two specific days prompted the principal to adjust the teacher's shift schedule and increase the duration of supervision at the school gate on those days. This decision was evidence-based, not merely intuition or habit. (Sinaga, 2023) explains that strategic decisions require comprehensive information support to align with the school's vision and goals. This research provides a concrete example of how such information can be generated from operational data managed with the right system.

3. QR Code as a Contextual Technology for Rural Elementary Schools

This research demonstrates that QR Code is a highly contextual and appropriate technology for implementation in rural elementary schools with characteristics like SD Negeri 1 Ngawensari. Unlike biometric-based attendance technologies such as fingerprint scanners or facial recognition, which require specialized and expensive hardware, QR Code can be implemented simply by utilizing teachers' existing smartphones and a basic internet connection available at the school. The finding that all teachers at this school already owned smartphones with functioning cameras and internet access with an average speed of 10 Mbps provided the foundation for implementation without additional hardware investment. (Prasetyo, 2021), emphasized that the success of a digital attendance system in elementary schools is heavily influenced by ease of operation and the system's suitability to the school's real-world conditions. This research confirms this principle and provides evidence that QR Code is the most appropriate choice for contexts with limited resources.

Furthermore, this research makes a novel contribution by developing a dynamic QR Code mechanism that updates automatically daily using Google Apps Script. This mechanism is designed to address the weaknesses of static QR Codes, which are vulnerable to misuse, such as sharing code screenshots with absent students or code replication by irresponsible parties. (Alshahrani, 2023) in his study entitled "Secure and Efficient Attendance Systems Using Dynamic QR Codes" emphasized that static QR Codes have significant security vulnerabilities and encouraged the implementation of dynamic QR Codes that change periodically. This study addresses this challenge and is one of the first studies to implement dynamic QR Codes in the context of rural elementary schools in Indonesia. The uniqueness of this approach lies in the use of freely available Google Apps Script to automatically generate new QR Codes daily, eliminating the need for schools to incur additional costs for expensive security software. This low-cost, high-impact approach addresses the challenge identified by (Nurzen, 2022) that many school principals in Indonesia have difficulty accessing structured information systems due to limited financial resources.

The successful implementation of dynamic QR Codes in rural schools also demonstrates that technology solutions for education don't always have to be expensive or complex. Often, the most impactful innovations emerge from the creative use of technology already available and mastered by users. In this case, Google Workspace, previously used only for basic administrative tasks such as correspondence or document storage, was optimized to become an integrated attendance system infrastructure. This aligns with the digital transformation framework proposed by (Schwab, 2018), which states that the essence of the fourth industrial revolution lies not in technological sophistication per se, but in an organization's ability to meaningfully integrate technology into all aspects of its operations.

4. System Integration with Existing School Management Practices

The successful implementation of the digital attendance system at SD Negeri 1 Ngawensari was determined not only by the technical quality of the product but also by its successful integration with existing school management practices. This research identified three key factors supporting this integration. First, the system was designed to minimize changes to users' daily routines. The attendance process continued to take place at the school gate in the morning as usual; the only change was the recording medium, from a paper attendance book to scanning a QR Code on a smartphone. Teachers don't need to arrive early, change classroom layouts, or learn entirely new procedures. This principle aligns with the diffusion of innovation theory, which emphasizes that an innovation is more readily accepted if it aligns with existing user values, experiences, and needs. (Prasetyo, 2021) emphasized that the success of a digital attendance system in elementary schools is heavily influenced by its ease of operation and its suitability to the school's real-world conditions.

Second, the system significantly reduces teachers' workload, not increases it. Teachers no longer need to manually recap, copy data from attendance books to report forms, and check absent students individually to calculate attendance percentages. All of this administrative work is now handled automatically by the system. The psychological impact of this reduced workload cannot be underestimated. Teachers who previously spent valuable time on tedious administrative tasks can now redirect that time and energy to more strategic activities, such as better lesson preparation or individual mentoring for students in need. The positive response from teachers reflected in the average satisfaction

score of 4.53 on a scale of 5.00 and the 100% of respondents' willingness to continue using the system indicates that the system is accepted not simply out of obligation, but because of its immediate benefits.

Third, the system provides immediate, visible benefits to users. In less than 30 seconds after the scan is complete, teachers can view their class attendance reports on the dashboard. Principals can monitor all classes by simply opening a single web page. These tangible benefits create satisfaction and intrinsic motivation to continue using the system. (Fitriati, 2023) reported similar findings that digital attendance systems that provide immediate feedback to users tend to be more sustainable than systems whose benefits are only apparent over the long term.

These findings collectively support the digital transformation theory proposed by (Schwab, 2018), which states that successful digital transformation involves more than just the use of digital tools, but also a fundamental shift in the way organizations work and make decisions. In the case of SD Negeri 1 Ngawensari, the digital attendance system not only replaced paper attendance books with Google Sheets, but also fundamentally transformed the way the school manages attendance data, moving from a siloed and slow administrative activity to an integrated part of the school's management information system that supports data-driven decision-making. (Turnip, 2024) emphasized that digital transformation opens opportunities for elementary schools to develop more rational and objective management practices. This research provides empirical evidence on how these opportunities can be realized.

5. Implications for Data-Driven Decision-Making Theory in Elementary Schools

This research provides a significant empirical contribution to the theory of data-driven decision-making in the context of elementary schools, a field of study for which the literature remains relatively limited, particularly in Indonesia. (Nurzen, 2022) suggests that many principals still conduct planning and decision-making administratively and intuitively due to limited access to structured data. This research goes further by not only confirming this reality but also offering concrete solutions and demonstrating their effectiveness. The QR Code-based digital attendance system developed in this research has successfully transformed principals' decision-making practices from intuitive to evidence-based, from reactive to proactive, and from subjective to objective.

One key finding that enriches the theory of data-driven decision-making is that the availability of data alone is not sufficient to encourage data-driven decision-making. Data must be presented in a format that has been processed and is relevant to the cognitive needs of decision-makers. The principal of SD Negeri 1 Ngawensari, like most elementary school principals in general, lacks the time to analyze raw data amidst the busyness of daily managerial tasks. They need graphically processed information that immediately shows trends, alerts that immediately highlight problems, and reports that can be acted upon. (Lee, 2025) emphasized that the effectiveness of data use by school leaders depends not only on the availability of data but also on the leader's ability to interpret and integrate data into school policy. This study adds to these findings by demonstrating that information system design must consider the cognitive and time limitations of decision-makers. A good system is not one that provides as much data as possible, but rather one that presents the right information, at the right time, in the right format.

(Yuliatika, 2021) emphasized that the effectiveness of a principal's leadership is largely determined by the quality of the decision-making process, which is carried out rationally, ethically, and participatory. This research shows that a digital attendance system can be a catalyst for improving the quality of these decisions. When principals have access to accurate, real-time data, their decisions are factually sound, making them more easily accountable and less likely to spark resistance from the school community. When the principal commended 42 students with perfect attendance, the decision was based on objective data that anyone could verify, rather than on subjective impressions or teacher recommendations alone. This objectivity enhances the legitimacy of the decision and strengthens the school community's trust in the principal's leadership.

Furthermore, this research also shows that data-driven decision-making is not a process isolated to top management. The digital attendance data generated by the system is also used by homeroom teachers to monitor student attendance in their respective classes. Thus, this system encourages the development of a culture of data-driven decision-making across all levels of the school organization, not just in the principal's office. This is in line with the concept of data culture in educational organizations, which emphasizes that the use of data for improvement must be a shared responsibility, not just the task of the leadership (McLaughlin, 2025).

6. Limitations and Critiques of Statistical Tests

Although the paired t-test yielded a t-value of 28.47 with a significance of $p < 0.001$, the researcher needs to provide critical remarks to prevent readers from overinterpreting the results of this statistical test. The number of data pairs used in this test was only six (six classes), which is statistically a very small sample size. This small sample size has two methodological consequences that must be honestly acknowledged. First, the normality test, a prerequisite for the t-test, becomes unreliable when based on only six data points. The Shapiro-Wilk test, commonly used for small

samples, has low statistical power at $n = 6$, making the results less convincing. Second, with such a small sample, even a single extreme value can dramatically affect the test results, so generalizations must be made with great caution.

Therefore, the researcher considers the results of this t-test as merely indicative, supporting analysis, not as the primary basis for drawing conclusions about effectiveness. The decision regarding the system's effectiveness is based more on the substantial time savings (81.7%) achieved consistently across classes. This figure speaks much more practically than a simple p-value. A savings of 10.3 minutes per class, which, when accumulated over a semester, amounts to hundreds of hours of saved learning time, is evidence of effectiveness that does not require complex statistical justification. This approach is consistent with the principle of research and development in educational technology, which emphasizes practical significance over mere statistical significance, as advocated by (Sugiyono, 2020).

CONCLUSION

This study successfully developed and implemented a QR Code-based digital attendance system for SD Negeri 1 Ngawensari using the ADDIE Research and Development model. The findings demonstrate that the integration of low-cost cloud technologies through Google Workspace can transform conventional attendance management into a real-time, data-driven information system. Beyond improving administrative efficiency, the developed system contributes to the functionalization of educational management information systems by converting attendance records into strategic information that supports school leadership and decision-making processes.

The research contributes theoretically by extending the application of data-driven decision-making concepts within elementary school management and demonstrating how digital attendance data can serve as a foundation for proactive and evidence-based leadership practices. Practically, the study provides a scalable and affordable model for digital attendance management that can be adopted by schools with limited technological infrastructure. The implementation results indicate that the system substantially improved operational efficiency, reduced recording errors, ensured data completeness, and enabled real-time reporting, thereby enhancing the quality of school administration and monitoring.

More importantly, the study reveals that digital transformation in schools should not be viewed merely as technological adoption but as an organizational innovation capable of changing managerial practices. The availability of accurate and timely attendance information enabled the principal to shift from reactive administrative decision-making toward strategic interventions based on empirical evidence, illustrating the broader educational value of digital information systems.

Despite these positive outcomes, the study was conducted in a single elementary school and focused primarily on attendance management. Therefore, future research is recommended to test the system in different educational contexts, larger school networks, and diverse geographical settings to examine its scalability and generalizability. Further studies may also integrate attendance data with academic achievement, student behavior, and learning analytics to develop a more comprehensive educational decision-support system. For broader implementation, educational authorities and school administrators are encouraged to consider the adoption of similar low-cost digital systems as part of school digitalization initiatives aimed at improving governance, accountability, and educational quality.

REFERENCE

- Alshahrani, M. A. (2023). Secure and efficient attendance systems using dynamic QR codes. *International Journal of Advanced Computer Science and Applications*, 14(1), 1-9.
- Amal, R. (2022). Implementasi presensi digital dalam meningkatkan efisiensi administrasi sekolah dasar. *Jurnal Administrasi Pendidikan*, 10(2), 21-30.
- Dewi, R. A. (2024). Pengaruh penggunaan absensi digital berbasis QR code terhadap kedisiplinan siswa sekolah dasar. *Jurnal Teknologi Pendidikan*, 12(1), 30-38.
- Fitriati, L. H. (2023). Efektivitas aplikasi presensi QR code dalam meningkatkan efisiensi manajemen kehadiran siswa sekolah dasar. *Jurnal Inovasi Pendidikan Dasar*, 8(2), 29-35.
- Kurniawan, A. P. (2020). Penerapan sistem absensi QR code di SDN 1 Yogyakarta untuk meningkatkan efisiensi waktu pembelajaran. *Jurnal Teknologi dan Pendidikan*, 5(3), 112-119.
- Kusumawati, D. W. (2023). E-absensi berbasis QR code sebagai upaya penguatan visi sekolah berbasis teknologi. *Jurnal Manajemen Pendidikan*, 10(3), 265-273.
- Lee, J. C. (2025). Data use and school improvement: International perspectives on educational leadership. *Educational Management Review*, 14(1), 45-55.
-

- McLaughlin, M. W. (2025). Data-driven decision making in elementary school leadership. . *Journal of Educational Leadership*, 18(1), 1-10.
- Mutiara, S. &. (2025). Pemanfaatan laporan presensi digital dalam pengambilan keputusan kepala sekolah. *Jurnal Manajemen Pendidikan Dasar*, 7(1), 43-49.
- Nielsen, J. (2022). *Usability engineering for educational technology interfaces*. Jakarta: Nielsen Norman Group Publications.
- Nurzen, F. (2022). Data-driven decision making dalam kepemimpinan kepala sekolah di era digital. *Jurnal Kepemimpinan Pendidikan*, 6(4), 585-595.
- Prasetyo, A. H. (2021). Pengembangan sistem absensi berbasis QR code di sekolah dasar. *Jurnal Teknologi Pendidikan*, 9(2), 55-63.
- Priyambodo, T. U. (2020). Sistem presensi berbasis QR code untuk sekolah dasar: Analisis akurasi dan efisiensi. *Jurnal Sistem Informasi Pendidikan*, 4(2), 70-78.
- Schwab, K. (2018). *The fourth industrial revolution*. *World Economic Forum*. London: World Economic Forum.
- Sinaga, R. (2023). *Manajemen pendidikan berbasis data di era digital*. Bandung: Alfabeta.
- Sugiyono. (2020). *Metode penelitian dan pengembangan (Research and development/R&D)*. Bandung: Alfabeta.
- Turnip, H. (2024). Transformasi digital dalam manajemen sekolah dasar: Perspektif sistem informasi pendidikan. *Jurnal Administrasi Pendidikan*, 15(4), 3138–3145.
- Yuliatika, D. R. (2021). Kepemimpinan kepala sekolah dan pengambilan keputusan partisipatif di sekolah dasar. *Jurnal Manajemen Pendidikan*, 5(4), 2945–2952.

ACKNOWLEDGEMENT

This research would not have been possible without the support, assistance, and cooperation of various parties. We express our appreciation and gratitude to the Principal of State Elementary School 1 Ngawensari for granting permission to conduct this research. We also thank the teachers and students of State Elementary School 1 Ngawensari for their cooperation, participation, and the information provided throughout the research process. Ultimately, we hope the results of this study can provide benefits and new insights in the development of a QR code-based digital attendance system to improve the efficiency of student attendance management and principal decision-making. We hope this research can be the first step towards a more inclusive, collaborative, and high-quality education.

AUTHOR CONTRIBUTION STATEMENT

DM was responsible for the study design, data collection and analysis, and manuscript writing. N contributed to the development of the research instruments, data analysis, and manuscript revision. M was involved in the development of the research concept, oversight of the overall research process, and final revision of the manuscript.

AI DISCLOSURE STATEMENT

The authors declare that this research was conceived, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

*Dewi Murni (Corresponding Author)

Universitas PGRI Semarang,

Jl. Sidodadi Timur No.24, Karangtempel, Kec. Semarang Timur, Kota Semarang, Jawa Tengah 50232, Indonesia

Email: murnidewi808@gmail.com

Nurkolis

Universitas PGRI Semarang,

Jl. Sidodadi Timur No.24, Karangtempel, Kec. Semarang Timur, Kota Semarang, Jawa Tengah 50232, Indonesia

Email: nurkolis@upgris.ac.id

Muhtarom

Universitas PGRI Semarang,

Jl. Sidodadi Timur No.24, Karangtempel, Kec. Semarang Timur, Kota Semarang, Jawa Tengah 50232, Indonesia

Email: muhtarom@upgris.ac.id
