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PARIWARA: Implementation of an IoT-Based Digital Signage System For Real-Time Lecture Information

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Abstract

The application of Internet of Things (IoT)-based Digital Signage has been widely adopted as a medium for dynamic, interactive, and real-time information delivery across various sectors, including education. However, most prior studies have focused on the delivery of general campus information and have not specifically addressed the display of lecture schedules as part of Smart Classroom integration. This research gap is significant because unclear information about classroom usage schedules frequently causes practical problems, such as students entering the wrong class. This study aims to design and implement an IoT-based Digital Signage system named Pariwara, developed using the Laravel framework and a MySQL database, to display real-time lecture schedule information. The system was developed using the prototyping method, comprising requirements analysis, design, prototyping, customer evaluation, and test-and-release stages. The system was evaluated through blackbox testing and a User Acceptance Test (UAT) involving lecturers and students. The results show that all tested features functioned as intended, achieving a 100% success rate, with an average user satisfaction score of 4.5 out of 5. This study concludes that Pariwara successfully addresses the Smart Classroom's need for clear schedule information, although further development is still required particularly integration with attendance and academic information systems, as well as offline display capability.

1 Introduction

The application of Internet of Things (IoT)-based Digital Signage technology has become one of the key innovations of the digital era, particularly in supporting efficient and interactive information delivery (Setiyani et al., 2020). Digital Signage enables the display of information in various formats like text, images, and video that can be updated in real time through interconnected devices (Maulana, 2019). This technology can present information dynamically, attractively, and relevantly to user needs, thereby improving the effectiveness of communication across sectors, including education. IoT further enables automated information management and adaptive responsiveness, producing more integrated systems. In an educational context, IoT-based Digital Signage can help academic institutions communicate information more effectively such as lecture schedules, important announcements, and campus activities supporting the creation of a more modern learning environment (Gunawan, 2021).

A substantial body of research has examined the potential of Digital Signage as a more effective communication medium in educational institutions. Nugroho (2021) highlighted the role of Digital Signage as a dynamic and engaging information medium for improving the effectiveness of information delivery in educational settings, demonstrating that Digital Signage can address the limitations of conventional communication methods, which tend to be static and slow to respond to changing information. Nasution & Syachrodi (2021), working at Universitas Riau, further argued that web-based Digital Signage can meet the need for fast and up-to-date information delivery in academic institutions, showing how such systems can be integrated with campus information systems to simplify content management and distribution. A related study at Politeknik Pertanian Negeri Payakumbuh by Fachrurrazi & Hizli (2021) found that Digital Signage implementation improves the user experience through more structured and visually engaging information delivery.

Studies that integrate Digital Signage with IoT point to considerable potential for more sophisticated and efficient information delivery systems. Hilmy (2013), at UIN Alauddin, developed an IoT-based Digital Signage model capable of displaying real-time information through website integration, demonstrating that combining Digital Signage with IoT can simplify the information-update workflow without requiring manual intervention from an administrator. Ristyawan et al. (2018) explored the use of Raspberry Pi as a low-power platform for developing a flexible Digital Signage system capable of displaying multiple content formats, including text, video, and images, establishing Raspberry Pi as an efficient and affordable solution for educational environments. Separately, Heruwanto et al. (2018), at the Faculty of Engineering, Universitas Gadjah Mada, designed a Digital Door Sign system based on MAC address and Wi-Fi hotspot detection to accurately and continuously display lecturer attendance information. Collectively, these studies illustrate how IoT device integration can address communication needs across various environments, including academic institutions.

More recent work extends this line of research toward broader campus-scale and offline-resilient signage architectures. U. Penchalaiah et al.(2026) proposed a lightweight, Flask-based, polling-synchronized multimedia dissemination framework for smart campus environments that achieves sub-15-second update latency and zero manual downtime, illustrating how architecture choices affect update responsiveness at scale. Patil (2025) demonstrated a low-power, Wi-Fi-controlled LED matrix signage system for institutional notice boards, underscoring the continued relevance of eliminating manual, paper-based announcement workflows. (Rachakonda et al., 2025) implemented a microcontroller-based digital notice board that automatically fetches institutional announcements from a college website, offering a lightweight embedded-systems alternative to cloud-based approaches such as Pariwara. Notably, even these recent systems remain oriented toward general campus announcements or multimedia dissemination rather than the specific, structured display of lecture-scheduling data tied to individual classrooms confirming that the research gap identified below remains valid despite the rapid pace of publication in this area.

Although extensive research has been conducted on IoT-based Digital Signage, most of it continues to focus on general applications for real-time information delivery or on improving communication efficiency within educational institutions. To date, no study has specifically examined the development of Digital Signage purpose-built to display real-time lecture schedule information as part of Smart Classroom integration. This gap is increasingly relevant given the need of higher-education institutions to manage lecture schedules efficiently while supporting a technology-driven Smart Classroom concept.

The researchers conducted interviews with lecturers and academic staff in the Informatics Engineering Education study program at Universitas Muhammadiyah Surakarta to identify information-delivery needs within the campus environment. These interviews revealed that the Informatics Engineering Education program operates one Smart Classroom that functions as a shared common room, used by the entire academic community of the Faculty of Teacher Training and Education (FKIP) for meetings, receiving guests, and lectures. However, the current condition shows that the absence of clear, structured information about room-usage schedules frequently causes confusion among both undergraduate and graduate students including incidents of students entering the wrong classroom. A system capable of displaying room-usage and course-schedule information in real time is therefore needed to ensure efficient room utilization and provide convenient access to information for room users.

This research aims to close this gap in Digital Signage development by designing and implementing a prototype system named Pariwara, a cloud-based Digital Door Sign built with the Laravel framework, specifically designed to display real-time lecture schedule information. This prototype functions not only as a dynamic information-delivery medium but also as part of the broader Smart Classroom concept at Universitas Muhammadiyah Surakarta. The implementation of this system is expected to contribute to the development of the Smart Classroom concept in higher education and to serve as an innovative model for the application of IoT-based Digital Signage in academic environments.

2 Method

This study employed the prototyping method, following the process flow illustrated in Figure 1. This method emphasizes repeated iteration and continuous user involvement throughout system development, ensuring that user requirements are met as closely as possible (Berger & Beynon-Davies, 2009). Prototyping was selected because it facilitates iteration and direct user feedback, which are essential when developing an IoT-based Digital Signage system that must align with the specific needs of lecturers and students. According to (Sommerville, 2011), prototyping is particularly effective for projects requiring direct user interaction, especially when user requirements are not yet fully understood or are likely to change during development.

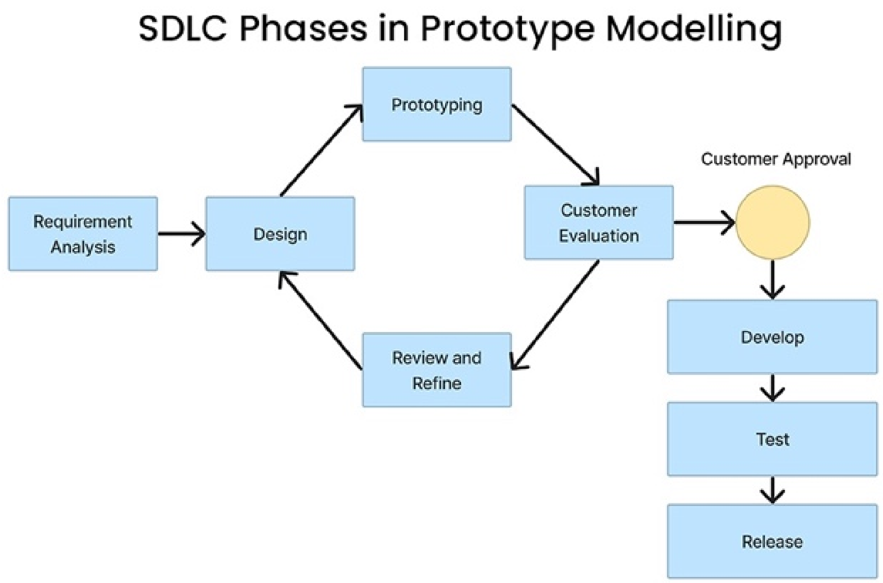

Figure 1. Research Method

Beyond this general justification, the choice of prototyping over alternative software development life-cycle models such as Waterfall or Agile/Scrum is further supported by studies on small-scale information systems with a limited, well-defined stakeholder group. Wulandari et al. (2021) noted that prototyping is particularly suitable when end users have difficulty articulating their requirements up front, allowing analysts to iteratively translate emerging needs into working prototypes, closely matching the situation encountered with lecturers and administrative staff in this study. Bjarnason et al. (2023), through a systematic mapping study and multi-case analysis, formalized prototyping into five key aspects (purpose, prototype scope, prototype media, prototype use, and exploration strategy), providing a more rigorous theoretical foundation for characterizing the prototyping instances applied in this project. (Tjahjono & Gosal, 2023) documented a directly comparable precedent: a Laravel-based web application developed using the Prototyping method and evaluated with UAT, which achieved a 96% user-satisfaction rate—supporting the appropriateness of pairing Laravel-based development with prototyping and UAT evaluation for small, stakeholder-intensive academic systems such as Pariwara.

2.1 Requirements Analysis Stage

The first stage of the Prototype method is Requirements Analysis. At this stage, user requirements were analyzed by combining a literature study with direct interviews with lecturers and academic staff in the Informatics Engineering Education program. These two complementary approaches were used to determine user requirements regarding the information to be displayed on the Digital Signage.

2.2 Design, Prototyping, Customer Evaluation, and Review-and-Refine Stages

The Design stage began with structuring the system architecture, including the database design for storing lecture schedule information and the workflow for displaying that data. The user interface (UI) was designed to align with the needs of Smart Classroom users. In the Prototyping stage, an initial digital door sign prototype was developed using the Laravel framework to build a web-based system, which was then deployed on hardware consisting of a mini PC and an LCD monitor, following the system architecture shown in Figure 2. This prototype was evaluated during the Customer Evaluation stage, in which lecturers and academic staff provided feedback through interviews and direct observation to assess the suitability of the features and interface. Based on this feedback, iterative refinement was carried out during the Review-and-Refine stage, focusing on both technical and design improvements. This iteration was repeated until the final prototype met user requirements and was ready for further testing.

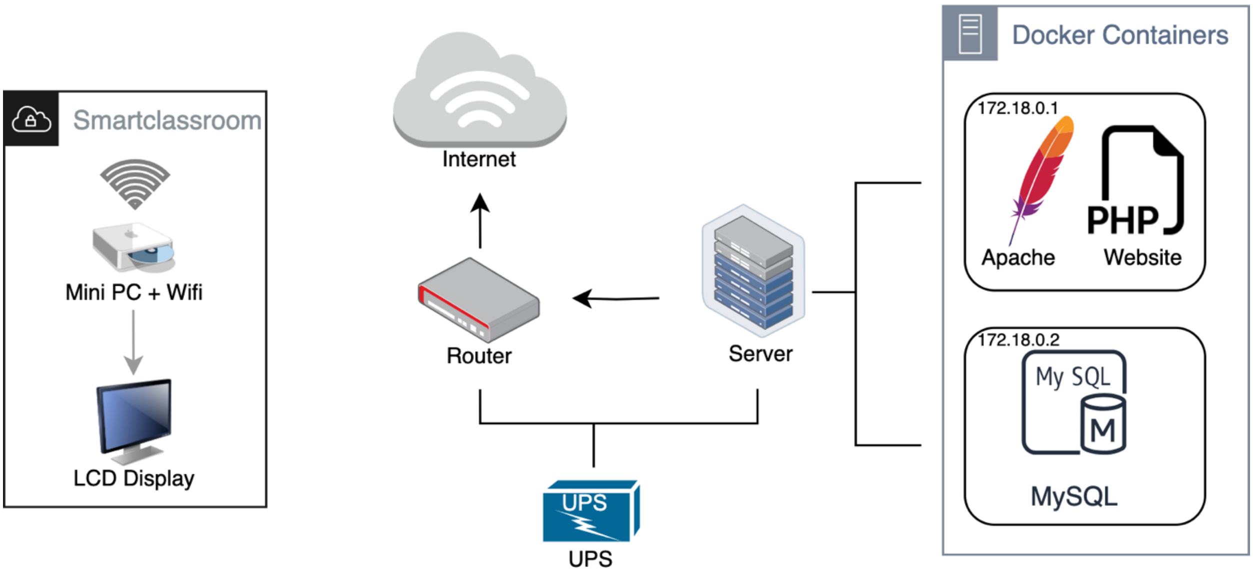

Figure 2. Pariwara System Architecture

2.3 Develop, Test, and Release Stages

During the Develop stage, the system was built based on the approved prototype, using the Laravel framework to implement agreed-upon features such as real-time schedule updates and Digital Signage display configuration on the hardware. System optimization was also carried out to ensure stable and responsive performance on the mini PC and LCD monitor.

After development, the Test stage assessed both functional and non-functional aspects, including feature validation, data accuracy, hardware compatibility, and performance testing to confirm that information updates met the required speed. Testing was conducted within the Smart Classroom environment to evaluate integration with existing infrastructure, and consisted of two complementary testing methods:

1. Blackbox testing, used to verify system functionality against the specified requirements without inspecting the underlying source code (Arif & Soko, 2022). This testing covered 12 primary scenarios addressing the create, edit, and delete operations for room data, lecturer data, course schedules,

and announcement data. Each scenario was executed by the researchers against its expected outcome, and the result was recorded as either ”passed” or ”failed.”

2. User Acceptance Test (UAT), used to evaluate whether the system meets end-user needs and is functionally acceptable in practice (Prabowo & Suprapto, 2021). The UAT was administered through a Google Form questionnaire built on a 1–5 Likert scale, covering four indicators: ease of use, speed of information access, clarity of the displayed schedule information, and visual appeal of the interface. The questionnaire was distributed to 10 respondents purposively selected from the primary user groups of the Smart Classroom, 3 lecturers and 7 students from the Informatics Engineering Education program chosen because they represent the two stakeholder groups who directly rely on the displayed schedule information in daily academic activities. This sample size was considered adequate for the purpose of this evaluation for two reasons. First, the target population itself is small and well-defined: the Smart Classroom evaluated in this study is used as a shared common room by one study program, so the pool of lecturers and students who regularly rely on its schedule information is inherently limited, making a purposive sample of key users more appropriate than a large-scale random sample. Second, this sample size is consistent with common practice in usability evaluation, where studies suggest that a small number of representative users (typically 5–15) is generally sufficient to surface the majority of usability issues in a system at the prototype-evaluation stage, particularly for small-scale, purpose-built systems rather than large public-facing applications. Respondents completed the questionnaire after directly observing and interacting with the deployed prototype in the Smart Classroom.

3 Results and Discussion

The product developed in this study is an IoT-based Digital Signage system named ”Pariwara,” designed to display real-time lecture schedule information in the Smart Classroom at Universitas Muhammadiyah Surakarta. The system consists of two main components: hardware and software. The hardware component is an HP Thin Client T628 mini PC as shown in Figure 3, connected to a 19-inch LCD monitor mounted at the front of the classroom.

Figure 3. HP Thin client T628

The software was developed using the Laravel framework and a MySQL database, comprising a backend module for administrators and a frontend module for public display. The admin system provides several features. Figure 4 shows the room-addition feature, through which users can add classrooms corresponding to the installation location of the Pariwara system. Figure 5 shows the lecturer-addition feature, through which users can add lecturer data, including photographs and names, which are then displayed on the Pariwara frontend.

Figure 4. Room-addition feature

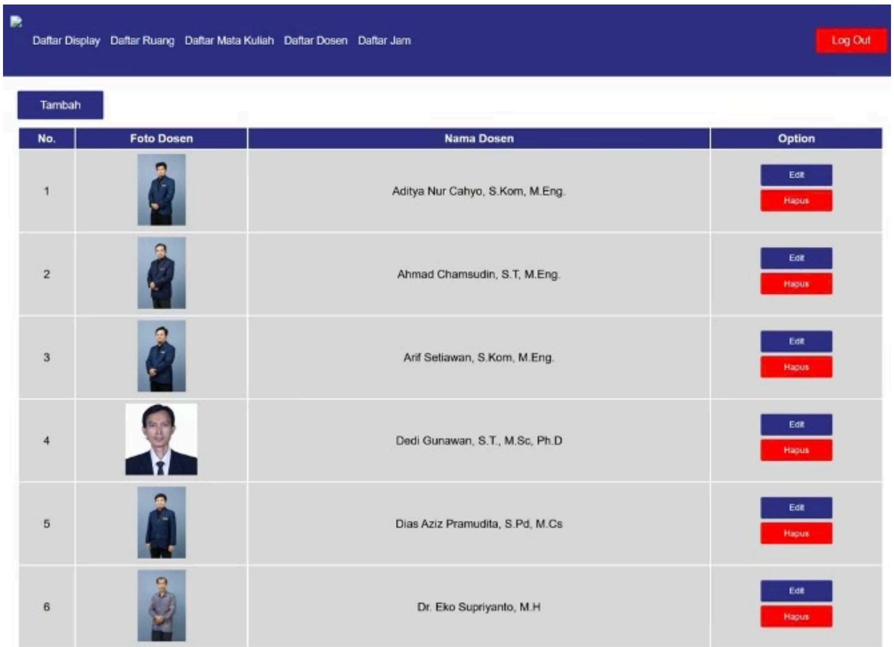

Figure 5. Lecturer-addition feature

Figure 6 shows the schedule-addition feature, through which users can add daily schedules, including room name, course, lecturer name, class time, class group, and day. Figure 7 shows the system's frontend display, which is presented on the LCD mounted at the front of the classroom. Once the frontend was finalized, the mini PC was configured to automatically open the frontend display upon startup, eliminating the need for daily manual configuration.

System testing was conducted using two methods: blackbox testing to evaluate system functionality, and a User Acceptance Test (UAT) to assess user acceptance of the developed system. Blackbox testing focuses on validating all features and functions against the specified requirements while UAT evaluates whether the system meets end-user needs and is functionally accepted Blackbox testing was carried out across 12 primary scenarios, covering the creation, editing, and deletion of room data, lecturer data, course schedules, and announcement data. All scenarios executed successfully without functional failure, achieving a 100% success rate. This result is consistent with comparable prototyping-and-blackbox-testing studies on Laravel-based systems. (Riyanti et al., 2024) similarly validated all seven blackbox scenarios for a Laravel-based rental application developed with the prototyping method suggesting that the 100% pass rate obtained for Pariwara is plausible for a well-scoped prototype rather than an artifact of insufficiently rigorous test-case design.

Figure 6. Schedule-addition feature

Figure 7. System's frontend display

The UAT involved 10 respondents consist of 3 lecturers and 7 students from the Informatics Engineering Education program, using a Google Form questionnaire structured on a 1–5 Likert scale. The evaluated aspects included ease of use, speed of information access, clarity of the schedule display, and visual appeal of the system interface. As shown in *Table 1*, the overall average score across all indicators was 4.5, indicating a very favorable user assessment. It is important to note that this study did not employ the System Usability Scale (SUS) instrument; the acceptance score reported here is the mean of the four Likert-scale indicators described above, not a SUS score. For comparative purposes, Antonius et al. (2025), who evaluated a prototyped point-of-sale information system, reported a SUS score of 85.8 ("excellent" usability) using a different instrument. Although the two scores are derived from different measurement instruments and are therefore not directly equivalent, both fall within the range typically interpreted as highly favorable user acceptance, suggesting that Pariwara's acceptance level is broadly consistent with results reported for comparable small-scale, prototyped academic and business information systems, rather than being an isolated or inflated result. It should nonetheless be noted that, with only 10 respondents, the UAT sample is small; this limits the extent to which the acceptance findings can be generalized beyond the specific Smart Classroom context studied here, and should be treated as an indicative rather than statistically representative result.

Table 1. UAT Testing Results

No.	Assessment Indicator	Likert Scale (1–5)	Average Score
1	Ease of use	1–5	4.6
2	Speed of information access	1–5	4.5
3	Clarity of displayed information	1–5	4.4
4	Visualization and interface design	1–5	4.5
	Overall average		**4.5**

Feedback from users identified a need for an additional feature that would allow the system to continue displaying information even if the internet connection is interrupted. This is an important consideration for future development, to make the system more robust against network-related technical constraints. Recent Digital Signage implementations have already begun to address this exact limitation: Gugan et al. (2025) describe "Digisign," a smart campus signage system that explicitly incorporates offline caching alongside real-time socket-based updates, allowing displays to continue functioning smoothly during network downtime. This provides a concrete, practically scaled precedent for extending Pariwara with a local caching mechanism. For example, storing the most recently retrieved schedule on the mini PC's local storage rather than requiring a heavier network-level caching architecture designed for large, multi-node IoT deployments.

The "Pariwara" system developed in this study offers several notable advantages compared to prior research. First, it is specifically designed to display lecture schedule information in real time, making it more targeted than general-purpose Digital Signage systems. Second, it complements the Smart Classroom features at Universitas Muhammadiyah Surakarta, supporting the digitalization of classroom information. Third, it directly addresses the previously identified problem of frequent classroom-usage errors caused by a lack of clear, real-time schedule information.

Compared with the study by Namatame (2020), this system is more advantageous because it is not only a dynamic information medium but is also specifically tailored to academic scheduling needs. The study by Nasution & Syachrodi (2021), which developed a similarly web-based Digital Signage system, resembles this work in its use of web technology; however, "Pariwara" is more tightly integrated with hardware within a Smart Classroom scenario. The studies by Hilmy (2013) and Ristyawan et al. (2018) emphasize IoT integration and the use of Raspberry Pi as a low-power device, whereas this study uses a mini PC, which offers more stable long-term performance. The system developed by Heruwanto et al. (2018) uses a MAC-address and Wi-Fi-hotspot approach to display lecturer attendance, whereas "Pariwara" focuses more specifically on classroom-schedule management and study-program information.

Positioning Pariwara against more recent smart-classroom literature further clarifies its niche. Sitepu et al. (2025) developed a comparable campus signage system using CodeIgniter and Android Set-Top-Box hardware at STMIK Kaputama, a useful point of comparison illustrating that the Laravel-plus-mini-PC combination adopted in this study is one of several viable architectural choices within the same problem space, rather than a uniquely optimal one. (Yağanoğlu et al., 2023) presented a substantially broader Smart Classroom implementation that additionally monitors environmental parameters (e.g., temperature and air quality) for energy-saving purposes, achieving high classification accuracy (98% in the best scenario); relative to this broader scope, Pariwara is deliberately narrower, trading environmental-sensing functionality for a sharper focus on schedule-display accuracy and clarity. (Dai et al., 2023) proposed a cloud-edge computing architecture for smart classrooms at Central China Normal University, reporting very high teacher and student satisfaction (100% and 97.14%, respectively) with a four-layer sensor-edge-network-platform design; while Pariwara does not adopt a comparably distributed edge-computing architecture, this comparison highlights cloud-edge distribution as a plausible direction for future scaling if Pariwara were deployed across multiple classrooms simultaneously rather than a single common room.

Nevertheless, the system still has limitations. The information displayed remains limited to text-based course schedules and announcements, without direct integration with an attendance system or other academic information systems. This represents a clear challenge for future development.

4 Conclusion

Based on the research and development conducted, it can be concluded that the IoT-based Digital Signage system ”Pariwara” was successfully developed and implemented to support real-time delivery of lecture schedule information in the Smart Classroom at Universitas Muhammadiyah Surakarta. The system has proven capable of addressing the problem of unclear classroom-usage information, which previously caused frequent confusion and misuse of the room by lecturers and students. Blackbox testing results showed that all functional scenarios performed as expected, while the User Acceptance Test (UAT) indicated a very favorable level of user satisfaction, with an average score of 4.5 out of 5 across the indicators of ease of use, access speed, information clarity, and visual appeal. These results demonstrate that Pariwara is not only technically functional but also positively received by users, within the bounds of the small (n = 10) evaluation sample used in this study.

Compared with previous research, Pariwara offers advantages in terms of a more focused academic-information function, integration with Smart Classroom features, and a Laravel-and-mini-PC implementation that provides high stability. Even so, the system still has limitations, including a restricted range of displayed information and dependence on internet connectivity. Future research is therefore recommended to integrate the system with attendance and academic information services to make the system more resilient to technical disruptions.

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